UNIVERSIDAD DE PUERTO RICO
RECINTO DE RIO PIEDRAS

Certificación Núm. 108
Año Académico 2020-2021

Senado Académico
Secretaría

Yo, Claribel Cabán Sosa, Secretaria del Senado Académico del Recinto de Río Piedras, Universidad de Puerto Rico, **CERTIFICO QUE:**

En la reunión ordinaria a distancia celebrada de forma asincrónica a partir de 6 de mayo de 2021, y culminada de forma sincrónica el 11 de mayo de 2021, se acordó por unanimidad:

- Aprobar el **Proposal for the Academic Revision of the Master of Science (M.S.) and the Ph.D. in Chemistry Programs and the Establishment of a Master of Arts (M.A.) in Chemistry Program,** de la Facultad de Ciencias Naturales

- La Propuesta forma parte de esta Certificación.

Y para que así conste, expido la presente Certificación bajo el sello de la Universidad de Puerto Rico, Recinto de Río Piedras, a los doce días del mes de mayo del año dos mil veintiuno.

Dra. Claribel Cabán Sosa
Secretaria del Senado

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Certifico correcto:

Dr. Luis A. Ferrao Delgado
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Anejo

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University of Puerto Rico - Río Piedras Campus
Faculty of Natural Sciences - Department of Chemistry
Chemistry Graduate Program

Proposal for the Academic Revision of the Master of Science (M.S.) and the Ph.D. in Chemistry Programs and the Establishment of a Master of Arts (M.A.) in Chemistry Program of the University of Puerto Rico, Río Piedras

Approval Dates:

Academic Affairs Committee of the Chemistry Graduate Program: March 3, 2020
Chemistry Graduate Program: March 17, 2020
Department of Chemistry: January 22, 2021
Graduate Board (Junta Graduada) of the College of Natural Sciences: February 5, 2021
Academic Affairs Committee of the College of Natural Sciences: February 17, 2021
Advisory Council for Graduate Studies and Research (CEGI): February 24, 2021
Academic Affairs Committee of the Academic Senate: April 20, 2021
Academic Senate: May 11, 2021 (Certification No. 108, Academic Year 2020-2021, Academic Senate)

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I. Preliminary Statement

The *Guidelines for the Drafting of Proposals for the Establishment of New Academic Programs at the University of Puerto Rico* (*June 2019*) (the *Guidelines*) of the Office of Academic Affairs of the Vice-presidency of Academic and Student Affairs, Research and Innovation, developed as required by the *Regulations for the Creation of New Academic Programs of the University of Puerto Rico* (Certification No. 64, 2018-2019, of the Governing Board of the University of Puerto Rico), specify that an order of presentation should be followed in any proposal for the establishment of a new academic programs. However, this is a proposal for the revision of the current M.S. and Ph.D. in Chemistry programs, as well as the establishment of a new M.A. in Chemistry (no thesis) program at the Río Piedras Campus of the University of Puerto Rico. We had been advised that if we wanted to revise one of our graduate programs and envisioned revising the other one and proposing a new one, we should take the opportunity and do all simultaneously. The Committee of Academic Affairs of the Chemistry Graduate Program that was in charge of preparing this proposal decided that due to the nature of a single proposal that presents the revision of two programs and the establishment of a new one, we had to change somewhat the order of presentation specified in the *Guidelines*. We therefore start first with an introduction to the document where we present the origins of the Chemistry Graduate Program some 60 years ago, its achievements so far, and the significant changes that it has undergone since its origin, followed by (a) a justification of the proposed changes, (b) the description and requirements of the current Chemistry Graduate Program, (c) the components of each of the two existing programs (the M.S. and Ph.D. programs), (d) a description of the proposed revision to the M.S. in Chemistry Program, (e) a description of the proposed new M.A. in Chemistry Program (no thesis), and (f) a description of the proposed revision to the Ph.D. in Chemistry Program. However, all components required of the proposal, as specified in the *Guidelines,* are included. The Narrative of the Proposal as specified in the *Guidelines* starts in page 18.

II. Introduction

The rapid industrial development in Puerto Rico and the world at the end of World War II created the need to train professionals with master's and doctoral degrees in the chemical area. Responding to this need, the Graduate Program in Chemistry was established in 1961 and began offering a M.S. degree, granting later in 1970 the Ph.D. degree. In 1981 a collaborative program

developed with the Department of Physics, leading to a Ph.D. program in Chemical Physics, was approved.

Among its most outstanding achievements is to have awarded up to the end of academic year 2019-2020 a total of 294 Ph.D. degrees and 199 M.S. degrees (40 of them in the 2015-2016 to 2019-2020 academic years). Another outstanding achievement has been the increasingly high number of papers published in peer-reviewed journals of high international recognition (305 within the 2010-2011 to 2014-2015 period and 219 during the 2015-2016 to 2019-2020 period). The Chemistry Graduate Program has also a strong track record of obtaining external funds ($48 million in the 6 years that ended in 2016 and $34 million in the 2015-2016 to 2019-2020 period). Finally, another outstanding achievement is that the professionals that graduated from the Chemistry Graduate Program are working successfully in various academic areas such as teaching and research, or industrial manufacturing, both in Puerto Rico and abroad.

There have been several significant changes undergone by the Chemistry Graduate Program since its establishment in 1961. The first was to begin offering a doctoral degree since 1970, a result of the need to develop scientific research for high-level research in the island competitive with the rest of the world. The second significant change was the elimination of the requirement of cumulative exams in 1995 on the understanding that it took too much time of the students which prevented them to focus earlier in scientific research. The third significant change in the Program was the implementation of Proposal A in 1997 to allow students to articulate early in their doctoral studies their thesis proposal and to begin the thesis research quickly. Another significant change was the formalization of rotations during the first semester of the students' entry to the Program that started in the year 2009 to help students choose their research mentor as quickly as possible after learning about the research carried out by at least three (3) professors in the Program.

The current Chemistry Graduate Program has two components:

a. Master of Science in Chemistry: The M.S. program consists of 42 credits and includes a seminar and a thesis requirement.
b. Ph.D. in Chemistry: The Ph.D. program consists of 75 credits, regardless of whether the student that joins the program has already a M.S. degree or not.

At the end of 2015 the Graduate Program and the Department of Chemistry approved a curricular revision of the M.S. in Chemistry Program so as to make it in compliance with Certification No. 38 of the Academic Senate, 2012-2013 Academic Year (Academic Policy for

Graduate Studies of the Río Piedras campus). We immediately continued discussions on a revision of the Ph.D. program that would include two tracks: one for students that enter the program with a B.S. degree and one for students entering with a M.S. in Chemistry or Chemical Engineering degree. We also started discussion on a Master of Arts degree in Chemistry program without a thesis requirement (M.A. in Chemistry). In addition, these discussions took in consideration the newly approved Certification No. 51 of the Academic Senate, 2017-2018 Academic Year (Academic Policy for Graduate Studies of the Río Piedras campus), which replaced Certification No. 38 and took effect at the start of the 2018-2019 Academic Year. More recently at the Department level we took in consideration Certification No. 95 of the Academic Senate, 2019-2020 Academic Year (Academic Policy for Graduate Studies of the Río Piedras campus), which replaced Certification No. 51 and took effect at the start of the 2020-2021 Academic Year.

Several statistics have prompted the Chemistry Graduate Program to revise its Ph.D. and M.S. programs. From a high of 136 students enrolled in the Chemistry Graduate Program in the 2005-2006 Academic Year, the program has experienced a decline in the number of enrolled students to an average of 83 students in the last six years (Academic Years 2014-2015 to 2019-2020). About 59% of the current graduate students are recruited from the University of Puerto Rico's System, while 9% are recruited from other Institutions around the Island, and 32% come from abroad (including the continental US). In recent years, the student population entering both the Chemistry Graduate Program (Ph.D. and M.S. programs) has declined from around 20 admitted incoming students enrolled per academic year to an average of 14 students per academic year in the last six years. The time to degree for the Ph.D. program has averaged 8-10 years, although for the 10 Ph.D. students who graduated at the end of the 2019-2020 Academic Year their average was 6.5 years and 5.3 years for the six that started in the program on and after 2013. On average (over the last five years), seven (Ph.D.) and one (M.S.) students graduate per year.

The proposed revisions to the Chemistry Graduate Program are aimed to address the academic reasons for the recent decline in the recruitment of graduate students and the extensive time to degree completion currently present in the program. In addition, the proposed revisions are expected to fulfill the following purposes: (1) to adjust the curricula to the current tendencies in the field of Chemistry; and (2) to bring the program in compliance with the Academic Policy for Graduate Studies of the Río Piedras campus (Certification No. 95 of the Academic Senate, 2019-2020 Academic Year).

III. Justification of changes

The revision of the M.S. and Ph.D. in Chemistry programs, as well as the creation of the new M.A. in Chemistry program, are justified by the following two reasons: (1) our current programs are not in compliance with Certification No. 95 of the Academic Senate, 2019-2020 Academic Year (Academic Policy for Graduate Studies of the Río Piedras campus) and (2) the current programs need to be updated to reflect the current educational and research trends in the field of Chemistry in order to better serve the current needs of our graduate students.

For a M.A. or M.A. program to comply with Certification No. 95 it must have as a requirement for graduation a maximum of 30 credits. In addition, at least 50% of enrolled students must graduate in four (4) years. Our current M.S. Program has a requirement of a minimum of forty-two (42) credits for graduation and more than 50% of our graduate students do not complete their degree in four years. For a Ph.D. Program to comply with Certification No. 95 at least 60% of enrolled students must graduate in seven (7) years. Currently our students take eight (8) to ten (10) years to graduate. Therefore, our current M.S. and Ph.D. Programs are not in compliance with Certification No. 95 with applies to all Masters and Ph.D. programs of the University of Puerto Rico, Rio Piedras Campus.

Moreover, in addition to the revisions made in order to comply with Certification No. 95, the Chemistry Graduate Program decided to take this opportunity to revise both programs to implement some of the current trends at the graduate level we have observed in other successful Chemistry Programs. We examined the requirements of the Top Ten Chemistry Graduate Programs in the USA (California Institute of Technology, Massachusetts Institute of Technology, University of California-Berkeley, Harvard University, Stanford University, University of Illinois, Northwestern University, Scripps. University of Wisconsin-Madison, and Cornell University, as well as those of selected Chemistry Graduate Programs in the USA that are comparable to our Chemistry Graduate Program in terms of publications, number of grants and facilities (Florida State University and New Mexico State University). A recent report by a Presidential Commission of the American Chemical Society (ACS) on graduate education[1] concludes that "current educational opportunities for graduate students, viewed on balance as a system, do not provide sufficient preparation for their careers after

1. *Advancing Graduate Education in the Chemical Sciences: Summary Report of an ACS Presidential Commission.* American Chemical Society: Washington, DC, 2013, p. 4.

graduate school". The Commission also concluded that "the state of graduate education in the chemical sciences is productive and healthy in many aspects, but has not kept pace with the significant changes in the world's economic, social, and political environment since the end of World War II, when the current system of graduate education was formed." The Commission also states that "the primary purpose of graduate education is education", with a first focus being "to educate students to solve problems in society, including the effective education of the succeeding generations". At the Master's level, the Commission states that the focus is to "develop scientists and engineers with augmented technical knowledge beyond the undergraduate level, sometimes toward specialized professional capabilities". As a graduate program, we believe that scientific writing is one of such professional capabilities.

In addition, in the 2015-2016 Academic Year, a survey of the students in the Chemistry Graduate Program that we conducted as part of the Self-Evaluation of the program indicated the generalized dissatisfaction with the Program. Students expressed their concerns that the Program was not up-to-date and did not prepare them with the skills needed in today's world and employment opportunities, resonating with the conclusions made by the Presidential Commission of the ACS. A total of forty-seven (47) students out of eighty-two (82) enrolled in the Graduate Program at that time completed a questionnaire and provided input on the proposed Chemistry Graduate Program revisions. The composition of the student population that responded to the survey was: 85% Ph.D. students, and 15% Master's students. The students were, in general, dissatisfied with the limited core and elective course offerings, and between neutral to satisfied with the core and elective course quality. A total of 37% of the students stated that they have taken courses from other Departments. Of the students surveyed 91% agree that it would be beneficial for a doctoral student to be able to apply for a Master's of Chemistry Degree after they have completed 30 credits of combined course work/research. In addition, 87% agreed that the Graduate Program should provide opportunities for professional certifications together with the Master's or Ph.D. degree. Furthermore, 85% thought it would be beneficial for students to take a course in Scientific Writing or Grant Writing.

The Chemistry Graduate Program has developed the following proposal to revise the current M.S. and Ph.D. programs and to create of a new M.A. program with no thesis based on both the need to comply with Certification No. 95 and the need to update our Program to reflect the current educational and research trends observed in other successful Chemistry Programs. The program decided that the no thesis option would be for a M.A. degree, not M.S., since we believe that in an

experimental science such as is Chemistry, a Master's degree should require the preparation and presentation of a publishable thesis in order to be a M.S. degree. Other well-known programs that agree with us and only offer a M.A. degree with no thesis are: Harvard University, Indiana University, University of California-San Barbara, University of Southern California, City University of New York, Texas State University, and Texas Christian University. They all consider, as we do, that a Master's in Chemistry Program without a thesis requirement should be a M.A. program. We believe a M.A. degree option will be attractive to a target population, which finished their B.S. degree some time ago, are professionals in academia, industry, or government and would like to obtain an advance degree, but do not have the time available to do intensive research in a laboratory in order to obtain publishable results for a thesis. We have received inquiries to our program in the past on whether we offer that non-thesis option.

We expect that these changes will improve the overall quality of the Program in terms of graduation rate and productivity, as well as serve to better develop capabilities in our graduates in order to provide them sufficient preparation for their professional careers after graduate school.

IV. Description and requirements of the current Chemistry Graduate Program

A. Vision and mission

a. **Vision:** The Chemistry Graduate Program aims to become one of vanguard, endowed with human resources (students, researchers and support staff), the infrastructure and the necessary fiscal resources to achieve and maintain excellence in education, knowledge transfer and scientific research. The Graduate Program is committed to the formation of the student of Chemistry and lifelong learning, creation and dissemination of knowledge at national and international level and the training of professionals of chemistry that promote scientific, social, and economic development, to improve the quality of life in Puerto Rico, the Caribbean, and the world.

b. **Mission:** The mission of the Chemistry Graduate Program is to educate and train professionals with knowledge in the fundamentals of chemistry, while providing an enabling experience in a specific area belonging to one of the classic branches or emerging interdisciplinary branches such as materials science, bioinorganic chemistry, supramolecular chemistry and nanotechnology, among others. The preparation of professionals in chemistry at an advanced level also seeks to develop in them the importance of creating a safe environment in the work area, the ability to

identify major problems in the discipline and to design effective strategies for solving them by encouraging good laboratory practices, interdisciplinarity and collaboration at the departmental, national, and international level. In a broader context, the mission of the Graduate Program is to prepare professionals to practice their profession with the firm intention of advancing knowledge in chemistry, bringing this knowledge to solve problems of daily life and human welfare.

B. Current alumnus profile

At the end of their graduate studies, students are expected:

a. To master the fundamental concepts of Chemistry, its various applications in daily life, and its relationship with other scientific disciplines.
b. To master the technical skills required to exercise the Chemist profession.
c. To show mastery of knowledge, competence in instrumentation and technical skills within their specialty in Chemistry.
d. To carry out scientific, creative, critical and innovative research, to offer solutions and generate knowledge framed in the ethical-professional commitment.
e. To know the scientific literature and handle the information in a critical, effective and ethical way to solve problems.
f. To effectively communicate the fundamentals of the discipline to the scientific community and diverse groups in a clear and logical way.
g. To exercise independence of criteria and show creativity and initiative to contribute to the solution of issues and problems related to Chemistry and the sciences, arts and companies related to it.
h. To integrate theories, practical protocols that protect the environment and ethical and safety codes to their professional or research work.
i. To incorporate instrumentation and current technological resources as support tools in the design of experiments and problem solving.
j. To have the capacity for individual learning and professional improvement.
k. To show commitment to the protection of natural, environmental, and cultural resources through the best practice of chemistry and occupational safety and environmental protection standards.
l. To show respect for human rights through actions of social inclusion and

commitment to diversity.

m. To demonstrate collaborative research actions by working in multi, inter- and transdisciplinary teams.

n. To assume and promote leadership that contributes to individual and collective transformations.

o. To identify important problems inherent to Chemistry and other disciplines to design strategies and/or effective experiments to solve them.

V. Program components for the existing degrees

A. **Master's of Science in Chemistry:** The current M.S. in Chemistry program consists of 42 credits. The current M.S. in Chemistry requirements are tabulated in this section.

1. Graduation Requirements (Table 1):

a. **General requirements:** Master's Program candidates must comply with the general graduation requirements that are mandated by the University of Puerto Rico - Rio Piedras Campus (UPR-RP) Campus.

b. **Curriculum requirements:**

i. **Course Work –** Complete a minimum of fifteen (15) credits in graduate courses. During their first year, the graduate student must consult with the Graduate Program Coordinator about which courses to take prior to enrollment. Beyond their first year, graduate students must consult their thesis adviser about which courses to take prior to enrollment. The thesis adviser might recommend the student to take courses in another discipline, for example, Biology, Physics, Environmental Science or Mathematics when these courses are deemed necessary for the student's development as an independent researcher.

- Twelve (12) credits of 6000 or 8000 level graduate courses (Core Courses).
- Three (3) credits in a graduate level elective course at an 8000 level.

ii. **Qualifying exams.** At the end of the first year in the Graduate Program, the students need to pass two (2) written qualifying exams. *The student must pass one qualifying exam in their area of specialty.*

iii. **Proposal A:** A research plan must be successfully defended in front of the student's Thesis Committee. This requirement also encompasses an oral exam in the student's area of specialty.

iv. **Graduate seminars:** The student must enroll and attend the graduate seminar course (QUIM 8901-8902) every academic year. The student needs to approve a minimum of two (2) credits. *The students must present one oral seminar as a Master's Thesis presentation.*

v. **Group research seminar meetings:** The student must enroll and attend the group seminars of their research group every academic year. The student needs to approve a minimum of six (6) credits.

vi. **Graduate research:** Enroll in a minimum of twelve (12) credits of graduate research. Based on their graduate research the student must write and successfully defend a Master's Thesis.

vii. **Teaching assistantship:** Enroll in at least one *academic* year (6 credits) of CHEM 6905-6906 Principles and Practices of Chemistry.

viii. **Thesis writing:** The student needs to enroll in the course CHEM 6896: Thesis Continuation. Based on their graduate research, the student must write a thesis representative of his/her contribution to science. *This is a zero credit course.*

c. **Additional requirements:**

i. **Placement exams:** Students are required to take five (5) entrance exams corresponding to the following department subdivisions: Analytical, Inorganic, Biochemistry, Organic, and Physical Chemistry**.**

ii. **Rotations (1 cr.).** The Students must participate of the graduate rotation program during the first semester of their first year in the Program. In this program the student most attend the rotating laboratory group meetings and pertinent research activities to gain a better understanding of the group's dynamics and research interests. The student needs to perform three (3) three-week rotations during a one-semester period. At the end of the first semester the student will choose a laboratory and therefore a thesis adviser for his/her Masters project.

iii. **GPA requirements:** Students must earn at least a C in each course and maintain an overall GPA of 3.0. A student that falls below a 3.0 GPA will be in a probation period of one year if the student entered as a regular student, and a probation period of one semester if the student entered the Program conditionally. Students that are not in good standing are not allowed to take the qualifying exams.

iv. **Thesis committee:** A thesis committee needs to be composed of five (5) faculty members, one of which needs to be the candidate's thesis adviser.

v. **Masters thesis seminar:** Based on their graduate research the student must successfully present and defend their thesis to the Graduate Program.

Table 1 shows a summary of the existing M.S. program requirements.

Table 1. Summary of the Existing Master's in Science Program Requirements.

Summary of the Existing Master's Program Requirements	Credits
Chemistry Graduate Courses (6000 level)	12
Electives Courses (6000 level)/(8000 level)	3
Teaching Assistantships (6905 Principles and Practices of Chemistry)	6
Laboratory Rotations	1
Qualifying Exams	0
Proposal A	0
Graduate Seminars	2
Graduate Research	12
Seminars	6
Thesis Writing	0
Total credits	*42*

2. Current course sequence

Table 2 shows the current course sequence for full-time students enrolled in the M.S. in Chemistry program.

Table 2. Current course sequence for **full-time** students enrolled in the Master's of Science in Chemistry program.*

First Year					
First Semester			Second Semester		
Course Code	**Description**	**Credits**	**Course Code**	**Description**	**Credits**
CHEM 6905	Principles and Practices	3	CHEM 6905	Principles and Practices	3
CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3	CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3
CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3	CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3
CHEM 8999	Laboratory Rotations	1	CHEM 8902	Graduate Seminar	1
CHEM 8901	Graduate Seminar	1	CHEM 8000	Seminar in Chemistry	2
	Total	*11*		*Total*	*12*

First Summer					
Milestone 1: *Qualifying Exams Period (pass at least two qualifying exam)*					
Second Year					
Third Semester			**Fourth Semester**		
Course Code	**Course Name**	**Credits**	**Course Code**	**Course Name**	**Credits**
CHEM 8000	Elective Course at the 8000 level	3	CHEM 8999	Graduate Research	6
CHEM 8999	Graduate Research	6	CHEM 8000	Seminar in Chemistry course at the 8000 level	2
CHEM 8000	Seminar in Chemistry course at the 8000 level	2	**Milestone 3: Master's Thesis:** Defense		
Milestone 2: Proposal A: Defense					
	Total	*11*		*Total*	*8*

*See list of graduate courses in Appendix 1. There are five Chemistry Graduate Core Courses (two semester courses, therefore actually ten courses) at the 6000 level, one for each one of the core areas of Chemistry: Analytical (CHEM 6215/6225), Biochemistry (CHEM 6811/6812), Inorganic (CHEM 6011/6012), Organic (CHEM 6411/6412) and Physical Chemistry (CHEM 6611/6612). The CHEM 8999 course is the Research for the Doctoral Dissertation course, but it is being currently used as a one credit course for the rotation requirement for incoming new graduate students in the program. There are five Seminar in Chemistry courses at the 8000 level (two semester courses, therefore actually ten courses), one for each one of the core areas of Chemistry: Seminar in Analytical Chemistry (CHEM 8205/8206), Seminar in Biochemistry (CHEM 8801/8802), Seminar in Inorganic Chemistry (CHEM 8005/8006), Seminar in Organic Chemistry (CHEM 8405/8406) and Seminar in Physical Chemistry (CHEM 8605/8606).

B. **Ph.D. in Chemistry:** The current Ph.D. in Chemistry Program consists of **75 credits**. The existing requirements are tabulated at the end of this section.

1. **Graduation requirements (Table 3):**

   a. General requirements: Program graduates must comply with the general graduation requirements that are mandated by the UPR-RP Campus.

   b. Curriculum requirements:

   i. Course Work – Complete a minimum of thirty (30) credits in graduate courses. During their first year, the graduate student must consult with the Graduate Program Coordinator about which courses to take prior to enrollment. Beyond their first year, graduate students must consult their thesis adviser about which courses to take prior to enrollment. The thesis adviser might recommend the student to take courses in another discipline, for example, Biology, Physics, Environmental Science or Mathematics when these courses are deemed necessary for the student's development as an independent researcher.

      1. Eighteen (18) credits of 6000 level graduate courses.
      2. Twelve (12) credits in graduate level electives; nine (9) of which should be at an 8000 level.

ii. **Qualifying exams.** At the end of the first year in the Doctoral Graduate Program, the students need to pass three (3) written qualifying exams**.** The student must pass one qualifying exams in their area of specialty.

iii. **Graduate seminars:** A minimum of two (2) graduate seminars must be presented and approved with a grade of A or B in front of the Graduate Program. One of these could be the Ph.D. Dissertation presentation.

iv. **Proposal A:** The presentation of the research work plan in front of the student's Thesis Committee.

v. **Proposal B:** The presentation and oral defense of an original research proposal in front of the student's Thesis Committee. This requirement also encompasses an oral exam in the student's area of specialty.

vi. **Group meetings:** The student must enroll and attend the group seminars of their research group every academic year. The student needs to approve a minimum of twelve (12) credits.

vii. **Graduate research:** Enroll in a minimum of twenty-four (24) credits of graduate research. Based on their graduate research the student must write and defend an acceptable Doctoral Thesis in front of the Graduate Program.

viii. **Teaching assistantship experience:** Enroll in at least one academic year (6 credits) of CHEM 6905-6906 Principles and Practices of Chemistry.

ix. **Candidacy:** The student should be recommended to be a candidate for a Ph.D. based on the academic achievement and performance in the qualifying exams. This promotion should take place within second (2) years from the date of admission to the Doctoral Program.

c. **Additional requirements:**

i. **Placement exams:** Students are required to take five (5) entrance exams corresponding to the following department subdivisions; Analytical, Biochemistry, Inorganic, Organic, and Physical Chemistry**.**

ii. **Rotations (1 cr.).** The Students must participate of the graduate rotation program during the first semester of their first year in the Program. In this program the student most attend the rotating laboratory group meetings and pertinent research activities to gain a better understanding of the group's dynamics and research interests. The student needs to perform three (3) three-week rotations during a one-semester period. At the end of the first semester the student will choose a laboratory and therefore a thesis adviser for his/her Doctoral research project.

iii. **GPA Requirements:** Students must earn at least a C in each course and maintain an overall GPA of 3.0. A student that falls below a 3.0 GPA will be in a probation period of one year if the student entered as a regular student, and a probation period of one semester if the student entered the Program conditionally. Students that are not in good standing will not be allowed to take the qualifying exams.

iv. **Thesis Committee:** A thesis committee needs to be composed of five (5) faculty members, one of which needs to be the candidate's thesis adviser.

v. **Doctoral Thesis Seminar:** Based on their graduate research the student must successfully present and defend their thesis to the Graduate Program. A limit of one year will be established for the thesis writing stage.

Table 3 shows a summary of the existing Ph.D. in Chemistry program requirements.

Table 3. Summary of the Existing Ph.D. Program Requirements.

Summary of the Existing Doctoral Program Requirements	Credits
Chemistry Graduate Core Courses (6000 level)	18
Electives Courses (6000 level)/(8000 level)	12
Teaching Assistantships (Principles and Practices)	6
Laboratory Rotations	1
Qualifying Exams	0
Proposal A	0
Proposal B	0
Graduate Seminars	2
Graduate Research	24
Group Meetings	12

Thesis Writing	0
Total credits	***75***

2. Current course sequence

Table 4 shows the current course sequence for full-time students enrolled in the Ph.D. in Chemistry program.

Table 4. Current course sequence for **full-time** students enrolled in the Ph.D. in Chemistry program.*

First Year					
First Semester			**Second Semester**		
Course Code	**Description**	**Credits**	**Course Code**	**Description**	**Credits**
CHEM 6905	Principles and Practices	3	CHEM 6906	Principles and Practices	3
CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3	CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3
CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3	CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3
CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3	CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3
CHEM 8999	Laboratory Rotations	1	CHEM 8902	Graduate Seminar	1
CHEM 8901	Graduate Seminar	1	CHEM 8000	Seminar in Chemistry	2
	Total	*14*		*Total*	*15*
First Summer					
Milestone 1: Qualifying Exams Period (pass at least three qualifying exam)					
Second Year					
Third Semester			**Fourth Semester**		
Course Code	**Course Name**	**Credits**	**Course Code**	**Course Name**	**Credits**
CHEM 6905	Principles and Practices	3	CHEM 6906	Principles and Practices	3
CHEM 6000	Elective Course	3	CHEM 6000	Elective Course	3
CHEM 8000	Seminar in Chemistry	2	CHEM 8000	Seminar in Chemistry	2
CHEM 8999	Graduate Research	3	CHEM 8999	Graduate Research	3
CHEM 8901	Graduate Seminar	1	CHEM 8902	Graduate Seminar	1
			Milestone 2: Proposal A: Defense		
	Total	*9/12***		*Total*	*9/12***
Third Year					
Fifth Semester			**Sixth Semester**		
Course Code	**Course Name**	**Credits**	**Course Code**	**Course Name**	**Credits**
CHEM 6905	Principles and Practices	3	CHEM 6906	Principles and Practices	3
CHEM 6000	Elective Course	3	CHEM 6000	Elective Course	3
CHEM 8000	Seminar in Chemistry	2	CHEM 8000	Seminar in Chemistry	2
CHEM 8999	Graduate Research	3	CHEM 8999	Graduate Research	3
CHEM 8901	Graduate Seminar	1	CHEM 8902	Graduate Seminar	1
			Milestone 3: Graduate Seminar Presentation		
	Total	*9/12***		*Total*	*9/12***
Fourth Year					
Seventh Semester			**Eighth Semester**		
Course Code	**Course Name**	**Credits**	**Course Code**	**Course Name**	**Credits**
CHEM 6905	Principles and Practices	3	CHEM 6906	Principles and Practices	3
CHEM 8000	Seminar in Chemistry	2	CHEM 8000	Seminar in Chemistry	2
CHEM 8999	Graduate Research	9	CHEM 8999	Graduate Research	3
			CHEM 8896	Dissertation Continuation	0
Milestone 4: Proposal B: Defense			**Milestone 5: Thesis Defense**		
	Total	*11/14***		*Total*	*5/8***

*See list of graduate courses in Appendix 1. There are five Chemistry Graduate Core Courses (two semester courses, therefore actually ten courses) at the 6000 level, one for each one of the core areas of Chemistry: Analytical (CHEM 6215/6225), Biochemistry (CHEM 6811/6812), Inorganic (CHEM 6011/6012), Organic (CHEM 6411/6412) and Physical Chemistry (CHEM 6611/6612). The CHEM 8999 course is the Research for the Doctoral Dissertation course, but it is being currently used as a one credit course for the rotation requirement for incoming new graduate students in the program. There are five Seminar in Chemistry courses at the 8000 level (two semester courses, therefore actually ten courses), one for each one of the core areas of Chemistry: Seminar in Analytical Chemistry (CHEM 8205/8206), Seminar in Biochemistry (CHEM 8801/8802), Seminar in Inorganic Chemistry (CHEM 8005/8006), Seminar in Organic Chemistry (CHEM 8405/8406) and Seminar in Physical Chemistry (CHEM 8605/8606).
**For students that due to financial reasons, need to continue being teaching assistants. The Ph.D. program has a one-year Teaching Assistant requirement.

VI. Description of the proposed changes to the revised M.S. in Chemistry Program

A. General description of the proposed revised M.S. in Chemistry program

1. **Title of the Program and Degree to be awarded:** The revised M.S. in Chemistry Program will be part of the **Chemistry Graduate Program** and will lead to Master's of Science in Chemistry degree with a subspecialty in Analytical, Inorganic, Organic, Physical Chemistry, or Biochemistry.
2. **Description of the program (Summary of the revised M.S. in Chemistry Program components):** The revised M.S. in Chemistry Program will consist of a maximum of 30 credits to be in compliance with Certification No. 95 of the Academic Senate, 2019-2020 Academic Year (Academic Policy for Graduate Studies of the Río Piedras campus). The revised M.S. in Chemistry requirements are tabulated at the end of this section.
3. **Program modalities:** The M.S. in Chemistry will be obtained through a combination of "in person" teaching, training and learning, and other non-traditional teaching/learning strategies, including hybrid and online distance education.
4. **Starting date of the revised M. S. in Chemistry program:** Academic Year 2021-2022.
5. **Duration of the revised M.S. in Chemistry program:** The expected duration of the program for full-time students will be <u>two (2) years</u> and for part-time students will be <u>three (3) years</u>. The maximum time to complete the program for full-time students will be four (4) years and for part-time students will be 5 years.

B. Professional accreditation

Although our campus' B.S. in Chemistry program is accredited by a professional association, the American Chemical Society (ACS), this professional organization does

not accredits graduate programs in Chemistry. Therefore, our Master's and Ph.D. programs are not eligible for accreditation from a professional association. By law, chemists in Puerto Rico working outside of academia but possess at least a B.S. in Chemistry degree and be licensed to practice the profession by the Chemists Examining Board of the Department of State of Puerto Rico.

C. Relation of the academic program with the current mission and Strategic Plan of the UPR and the Río Piedras Campus

The proposed revised M.S. in Chemistry Program is aligned with the current Mission and Strategic Plan 2017-2022 of the University of Puerto Rico (Certificate No. 50, 2016-2017, of the Governing Board) and with the Strategic Plan 2018-2023 of the Río Piedras Campus (Certificate No. 79, 2017-2018, of the Academic Senate). The program emphasizes (a) to achieve and maintain excellence in education, research and dissemination of knowledge, (b) a commitment to the integral formation of the student and his lifelong learning; (c) the dissemination of knowledge at the national and international level and (d) to contribute to the scientific, social and economic development of the country to improve the quality of life in Puerto Rico, the Caribbean and the world.

The Program is consistent with the Mission of the Río Piedras Campus in terms of providing graduate education of the highest quality that develops capacities for independent study and research and helps strengthen undergraduate education. In addition, in the training of professionals of the highest caliber, committed to the ideals and values of Puerto Rican society. Likewise, to develop teaching, research and development, and the dissemination of knowledge at an international level.

D. Conceptual Framework

1. **Vision:** We aim to develop lifelong learning, creation and dissemination of knowledge at national and international level and the training of professionals of chemistry that promote scientific, social, and economic development, to improve the quality of life in Puerto Rico, the Caribbean, and the world.
2. **Mission:** The mission of the M.S. program of the Chemistry Graduate Program is to educate and train professionals with knowledge in the fundamentals of chemistry, while providing an enabling experience in a specific area belonging to one of the

classic branches (Analytical Chemistry, Biochemistry, Inorganic Chemistry, Organic Chemistry, Physical Chemistry) or emerging interdisciplinary branches such as materials science, bioinorganic chemistry, supramolecular chemistry and nanotechnology, among others. The preparation of professionals in chemistry at an advanced level also seeks to develop in them the importance of creating a safe environment in the work area, the ability to identify major problems in the discipline and to design effective strategies for solving them by encouraging good laboratory practices, interdisciplinarity and collaboration at the departmental, national, and international level. In a broader context, the mission of the Graduate Program is to prepare professionals to practice their profession with the firm intention of advancing knowledge in chemistry, bringing this knowledge to solve problems of daily life and human welfare while instilling in our students hard and soft skills sets that will directly prepare them for post-graduate work and to promote scientific, social, and economic development to improve the quality of life in Puerto Rico, the Caribbean, and the world.

3. **Goals and Objectives:** The Chemistry Graduate Program is the product of an urgent need to create the intellectual resources needed to make Puerto Rico an attractive place for the development of new technologies and enterprises with capable personnel, who have the capacity of adapting to the changing paradigm of science and technology entrepreneurship while promoting scientific, social, and economic development in Puerto Rico, the Caribbean, and the world. The objectives of the program are:
    a. To provide the basic theoretical-practical knowledge required to perform as a competent professional in the area of chemistry
    b. To encourage scientific, creative and critical research, framed in the ethical - professional commitment.
    c. To contribute to the solution of issues and problems related to Chemistry and the sciences, arts and industries related to it.
    d. To advance the knowledge of Chemistry and ensure human well-being by providing ideas for solving problems in society beyond the research laboratory.

e. To link the University with the world reality to improve the well-being of the human being.
f. To contribute to the improvement of undergraduate programs through research opportunities, exchange of ideas and activities with graduate studies.
g. To offer chemical advice to the community, the country's educational system, the government, and industries.
h. To identify institutional and external funds to provide a physical and administrative infrastructure that allows sustaining and optimizing the operation of the program to efficiently serve a heterogeneous audience of students and professionals.

4. **Philosophy:** Both the Chemistry Department at UPR-RP and its Chemistry Graduate Program are dedicated to serve Puerto Rico by developing professionals capable of contributing to the scientific, technological, and socio-economic growth of Puerto Rico and the world.
5. **Proposed revised M.S. in Chemistry Program alumnus profile (in compliance with the Graduate Student Alumnus Profile of the Río Piedras Campus – Certification No. 104, 2016-2017 Academic Year, of the Academic Senate, see Appendix 2):** At the end of their graduate studies, students are expected:
    a. To conduct creative, critical and innovative scientific research to offer solutions and generate knowledge framed in an ethical-professional commitment as learned through problem solving based learning strategies in the program.
    b. To know and critically evaluate the scientific literature and methodology and use the obtained information in problem solving.
    c. To exercise independence of opinion and show creativity and initiative to contribute to the solution of matters and problems related to Chemistry and the sciences, arts, and enterprises related to it.
    d. To integrate theories and practical protocols that protect the environment and ethical and security codes in his/her professional and research endeavors.
    e. To know the scientific literature and manage information in a critical, effective and ethical way for problem solving.

f. To incorporate current instrumentation and technological resources as resource tools in the design of experiments and in problem solving.
g. To communicate effectively the fundamentals of his/her discipline to the scientific community and to diverse groups in a clear and logical manner.
h. To show commitment with the protection of natural, environmental, and cultural resources through Chemistry best practices and the occupational safety and environmental protection norms.
i. To show respect to human rights through actions of social inclusiveness and commitment to diversity.
j. To demonstrate collaborative research actions through multi-, inter-, and transdisciplinary teamwork.
k. To assume and encourage leadership roles that contribute to individual and collective transformations.
l. To master the fundamental concepts of Chemistry, of its diverse applications in daily life and its relationship with other scientific disciplines.
m. To master the technical skills required for the exercise of his/her profession as a chemist.
n. To show mastery of knowledge in instrumentation and technical skills within their specialty in Chemistry.
o. To identify important problems inherent to Chemistry and other disciplines to design effective strategies and/or experiments for their solution.
p. To show capacity to apply chemical knowledge, skills, and ethical conduct in the solution of real problems associated with the Chemistry field that promote scientific, social, and economic development to improve the quality of life in Puerto Rico, the Caribbean and the world.

6. **Coherence and sufficiency:** The components of the conceptual framework are coherent and sufficient and meet the conditions to provide the necessary structure to the proposed program. The harmony and logical and consequent relationship between the Mission, Goals, Objectives, and the Alumnus Profile allows the program to successfully continue to pursue its Vision.

E. Curricular design (proposed revised graduation requirements)

1. **General requirement:** The revised M.S. in Chemistry Program candidates must comply with the general graduation requirements that are mandated by the UPR-RP Campus.
2. **Curriculum Requirements (Table 5):**
   a. **Course Work: –** Complete a minimum of **eighteen (18)** credits in graduate courses. During their first year, the graduate student must consult with the Graduate Program Coordinator about which courses to take prior to enrollment. Beyond their first year, graduate students must consult their thesis adviser about which courses to take prior to enrollment. The thesis adviser might recommend the student to take courses in another discipline, for example, Biology, Physics, Environmental Sciences or Mathematics when these courses are deemed necessary for the student's development as an independent researcher.
      i. **Six (6) credits of 6000-8000 level graduate chemistry courses.**
      ii. **Twelve (12) credits in graduate level electives** at a 6000-8000 level. Including a Scientific Writing Course described below.
      (See list of courses in Appendix 1).
   b. **Rotations.** The students can voluntarily enroll in the graduate rotation course. In this course the student most attend the rotating laboratory group meetings and pertinent research activities to gain a better understanding of the group's dynamics and research interests. The student enrolled in the graduate rotation course needs to perform three (3) three-week rotations during their first semester in the Program. At the end of the first semester the student will choose a laboratory and therefore a thesis adviser for his/her Masters project. This is a zero credit course.
   c. **Research Plan Proposal:** A short research plan proposal (three pages) must be successfully defended in front of the student's Thesis Committee. This requirement also encompasses an oral exam in the student's area of specialty. If the student fails the research plan proposal defense, he/she will have one semester to repeat it. In the event that a student fails the research plan proposal examination on the second attempt, the student will be dropped from the

program. The research plan proposal should be completed by the end of the second (2^{nd}) semester of their (1^{st}) first year in the program.

d. **Graduate Seminars:** The student must enroll and attend the graduate seminar course (QUIM 8901-8902) every academic year. The student needs to approve a minimum of two (2) credits. The students must present one oral seminar as a Master's Thesis presentation.

e. **Focused Research Seminars:** The student must enroll and attend the focused research seminar of their research group every academic year (usually referred to as the "group meetings"). The student needs to approve a minimum of four (4) credits.

f. **Graduate Research:** Enroll in a minimum of six (6) credits of graduate research. Based on his/her graduate research the student must write and successfully defend a Master's Thesis.

g. **Progress Report Presentation:** The candidate must write and make an oral presentation to report the progress of the accomplished research performed during the course of the Master's no later than the third (3^{rd}) semester in the graduate program to the Thesis Committee Members (fourth semester for part-time students).

h. **Scientific Writing Course:** Enroll in a three (3)-credit scientific writing course. The course will serve to introduce scientific writing tools and methods, as well as develop the student's capabilities to adequately develop a Master's thesis and defense. The students will take this course during the first semester of the second year in the Graduate Program.

i. **Thesis Writing:** The student needs to enroll in the course CHEM 6896: Thesis Continuation. Based on their graduate research, the student must write a thesis representative of his/her contribution to science. *This is a zero credit course.*

3. **Additional requirements:**

a. **Placement Exams:** Upon acceptance into the Chemistry Graduate Program, students will be required to take an entrance placement exam to demonstrate basic knowledge in each of these areas: Analytical, Biochemistry, Inorganic,

Organic, and Physical Chemistry**.** The results of the placement exam will be shared with all professors of the Chemistry Graduate Program so that each division can assess how to help the student reach the academic standards that are expected for every graduate in the Chemistry Graduate Program. In addition, the results will be used to help develop the first annual Individualized Development Plan (IDP) for the student in conjunction with the division(s) and/or the Program Coordinator. The final IDP should be submitted and approved by the Graduate Affairs Committee. An annual IDP will be required for all graduate students in a format similar to the ChemIDP of the American Chemical Society (https:chemidp.acs.org) or the MyIDP of the American Association for the Advancement of Science (http://myidp.sciencecareers.org) throughout every year of the program.

b. **GPA requirements and optional candidacy exam:** Students must earn at least a **C** in each course and an overall GPA of 3.0 at the completion of the first year of courses to be in good standing and qualify to take the Ph.D. candidacy exam if the student wishes to transfer to the Ph.D. program. Students who earn more than a 2.5 but below 3.0 GPA and wish to transfer to the Ph.D. program will be allowed to take the first year Ph.D. candidacy exam but must repeat the course with the deficiency to raise their GPA to 3.0 upon completion of the second year. Students who earn less than a 3.0 GPA will be dropped from the program after the allotted probation period. If a student earns a GPA above 3.5 (with two A's in their area of specialty) and wishes to transfer to the Ph.D. program, the student will be exempt from the mandatory Ph.D. candidacy exam. The minimum GPA for graduation will be of 3.0 in a scale of 4.0. A student that falls below a 3.0 GPA will be in a probation period of one (1) year if the student entered as a regular student, and a probation period of one (1) semester if the student entered the Program conditionally. During the probation period research or teaching assistantships might not be available. Students that are not in good standing after the allotted academic probation period will be dropped from the Graduate Program.

c. **Candidacy:** The student should be recommended to be a candidate for a Master's in Science based on his/her academic achievements. A recommendation letter by the Academic Affairs Committee and the Program Coordinator of the Chemistry Department will be sent to the Register. This promotion should take place within a maximum of two (2) years from the date of admission to the Chemistry Graduate Program.

d. **Public speaking workshop:** A public speaking workshop will be offered to all graduate students once a year.

e. **Thesis committee:** A thesis committee must be composed of **minimum of three (3) members** with a Ph.D. or equivalent degree, one of which has to be the candidate's thesis adviser. At least one other committee member has to be a person with either academic or industrial expertise in the area of the candidate's dissertation research. The selection of the committee members needs to be approved by the thesis adviser in a prior agreement with the student. All members need to *participate (be present)* for the thesis defense to proceed; one of these members needs to be the thesis adviser.

f. **Master's Thesis seminar:** Based on their graduate research the student must successfully present and defend their thesis to the Graduate Program. The thesis presentation and defense will be public, although the final deliberations of the Thesis Committee will be private.

Table 5 shows a summary of the proposed revised M.S. in Chemistry program requirements.

Table 5. Summary of the Proposed M.S. in Chemistry Program Requirements.

Summary of the Proposed Revised M.S. in Chemistry Program Requirements	**Credits**
Chemistry Graduate Core Courses (6000 level)	6
Free Electives Courses (6000 level)/(8000 level)	9
Scientific Writing Course	3
Teaching Assistantships (Principles and Practices)	0
Laboratory Rotations	0
Candidacy Exam and Progress Report Meeting	0
Thesis Research Proposal	0
Graduate Seminars	2
Graduate Research	6
Focused Research Seminars	4
Thesis Writing	0
Total credits	***30***

4. Proposed revised M.S. program course sequence

Table 6 shows the proposed course sequence for full-time students enrolled in the revised M.S. in Chemistry Program.

Table 6. Proposed Course Sequence for **full-time students** enrolled in the revised Master's of Science in Chemistry Program.*

First Year					
First Semester			**Second Semester**		
Course Code	**Description**	**Credits**	**Course Code**	**Description**	**Credits**
CHEM 6905	Principles and Practices	3	CHEM 6906	Principles and Practices	3
CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3	CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3
CHEM 6000-8000	Elective Course***	3	CHEM 6000-8000	Elective Course***	3
CHEM 6000-8000	Elective Course***	3	CHEM 6999	M.S. Thesis Research	2
CHEM 6999	Laboratory Rotations	0	CHEM 8902	Graduate Seminar	1
			CHEM 8000	Focused Research Seminar	2
			Milestone 1: **Thesis Research Proposal**		
	Total	*9/12***		*Total*	*11/12***
Second Year					
Third Semester			**Fourth Semester**		
Course Code	**Course Name**	**Credits**	**Course Code**	**Course Name**	**Credits**
CHEM 6905	Principles and Practices	3	CHEM 6905	Principles and Practices	3
CHEM 8000	Scientific Writing Course	3	CHEM 8000	Focused Research Seminar	0
CHEM 8000	Focused Research Seminar	2	CHEM 6999	M.S. Thesis Research	1
CHEM 6999	M.S. Thesis Research	3	CHEM 6896	Thesis Continuation	0
CHEM 8901	Graduate Seminar	1			
Milestone 2: **Progress Report and Candidacy**			**Milestone 3**: **Thesis Defense**		
	Total	*9/12***		*Total*	*1/4***

*See list of graduate courses in Appendix 1. There are five Chemistry Graduate Core Courses (two semester courses, therefore actually ten courses) at the 6000 level, one for each one of the core areas of Chemistry: Analytical (CHEM 6215/6225), Biochemistry (CHEM 6811/6812), Inorganic (CHEM 6011/6012), Organic (CHEM 6411/6412) and Physical Chemistry (CHEM 6611/6612). The CHEM 8999 course is the Research for the Doctoral Dissertation course, but it is being currently used as a one credit course for the rotation requirement for incoming new graduate students in the program. There are five Seminar in Chemistry courses at the 8000 level (two semester courses, therefore actually ten courses), one for each one of the core areas of Chemistry: Seminar in Analytical Chemistry (CHEM 8205/8206), Seminar in Biochemistry (CHEM 8801/8802), Seminar in Inorganic Chemistry (CHEM 8005/8006), Seminar in Organic Chemistry (CHEM 8405/8406) and Seminar in Physical Chemistry (CHEM 8605/8606). We propose to change the name of the Seminar in Chemistry courses to Focused Research Seminar in Chemistry, maintaining their current course codes.

** For students that due to financial reasons, need to continue being teaching assistants. TA is not a requirement for Master's of Science students.

*** A student might take elective courses in areas other than Chemistry if in consultation with the advisor it is decided that taking that course(s) will help the student complete the thesis project.

The Chemistry Graduate Program offers courses in five areas of Chemistry: Analytical Chemistry, Biochemistry, Physical Chemistry, Inorganic Chemistry, and Organic Chemistry. During the first year in the program, students can take two core courses in two of these five areas. In later years, students

can take elective/advanced courses in their area of specialty, as well as elective courses from any other area (even from areas outside the Program, say courses from the Graduate Program in Biology, or Physics or Environmental Sciences, depending if the student and his/her mentor determine it is necessary to assist the student in their master's thesis or doctoral dissertation work). Core courses from the other areas that the student did not take courses in their first year in the program may be taken by these students as elective courses. All those courses currently have a code. For this reason, currently there is no elective course that is in the process of obtaining a code. Furthermore, there are advanced 8000 level courses called Special Topics Course for each of the five areas. In each area, with the same code, different courses of this type can be offered, just by changing the course title (for example, QUIM 8990-Special Topics in Inorganic Chemistry - Bioinorganic Chemistry and QUIM 8990-Special Topics in Inorganic Chemistry - Crystallography). These are state-of-the-art courses are offered on the latest and greatest issues in the area of Chemistry. Some of these courses have been offered for several years and there is interest in their conversion to separate courses with separate codes. But for this proposal for the revision of the M.S. and Ph.D. Chemistry programs and the establishment of the new M.A. in Chemistry program, we do not need to already have a code for those course since they are already being currently offered within a course with a code and can be taken as electives right now.

Table 7 shows the proposed course sequence for part-time students enrolled in the M.S. in Chemistry program.

Table 7. Proposed Course Sequence for **part-time students** enrolled in the revised Master's of Science in Chemistry Program.*

First Year					
First Semester			**Second Semester**		
Course Code	**Description**	**Credits**	**Course Code**	**Description**	**Credits**
CHEM 6905	Principles and Practices	3	CHEM 6906	Principles and Practices	3
CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3	CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3
CHEM 6000-8000	Elective Course***	3	CHEM 6000-8000	Elective Course***	3
CHEM 6999	Laboratory Rotations	0	CHEM 8000	Focused Research Seminar	2
			Milestone 1: **Thesis Research Proposal**		
		Total	*6/9***	*Total*	*8/11***
Second Year					
Third Semester			**Fourth Semester**		
Course Code	**Course Name**	**Credits**	**Course Code**	**Course Name**	**Credits**
CHEM 6905	Principles and Practices	3	CHEM 6906	Principles and Practices	3
CHEM 8000	Scientific Writing Course	3	CHEM 8000	Focused Research Seminar	0
CHEM 8000	Focused Research Seminar	2	CHEM 6999	M.S. Thesis Research	2
CHEM 6999	M.S. Thesis Research	2	CHEM 8902	Graduate Seminar	1
CHEM 8901	Graduate Seminar	1			
			Milestone 2: Progress Report Meeting and Candidacy		
		Total	*8/11***	*Total*	*3/6***

Third Year					
Fifth Semester			**Six Semester**		
Course Code	**Course Name**	**Credits**	**Course Code**	**Course Name**	**Credits**
CHEM 6905	Principles and Practices	3	CHEM 6906	Principles and Practices	3
CHEM 6000-8000	Elective Course***	3	CHEM 6896	Thesis Continuation	0
CHEM 6999	M.S. Thesis Research	1			
CHEM 8000	Focused Research Seminar	0	CHEM 6999	M.S. Thesis Research	1
Milestone 3: Progress Report			**Milestone 4**: **Thesis Defense**		
	Total	*4/7***		*Total*	*1/4***

*See list of graduate courses in Appendix 1. There are five Chemistry Graduate Core Courses (two semester courses, therefore actually ten courses) at the 6000 level, one for each one of the core areas of Chemistry: Analytical (CHEM 6215/6225), Biochemistry (CHEM 6811/6812), Inorganic (CHEM 6011/6012), Organic (CHEM 6411/6412) and Physical Chemistry (CHEM 6611/6612). The CHEM 8999 course is the Research for the Doctoral Dissertation course, but it is being currently used as a one credit course for the rotation requirement for incoming new graduate students in the program. There are five Seminar in Chemistry courses at the 8000 level (two semester courses, therefore actually ten courses), one for each one of the core areas of Chemistry: Seminar in Analytical Chemistry (CHEM 8205/8206), Seminar in Biochemistry (CHEM 8801/8802), Seminar in Inorganic Chemistry (CHEM 8005/8006), Seminar in Organic Chemistry (CHEM 8405/8406) and Seminar in Physical Chemistry (CHEM 8605/8606). We propose to change the name of these courses to Focused Research Seminar in Chemistry, maintaining their current course codes.

** For students that due to financial reasons, need to continue being teaching assistants. TA is not a requirement for Master's of Science students.

*** A student might take elective courses in areas other than Chemistry if in consultation with the advisor it is decided that taking that course(s) will help the student complete the thesis project.

Table 8 shows a comparative table for the current and proposed revised curriculum in the M.S. in Chemistry program.

Table 8. Table Comparing Current and Proposed Revised Curriculum in the Master's of Science in Chemistry Program.*

Current Curriculum			**Proposed Curriculum (Reduction of credits and inclusion/exclusion of non-credit requirements)**		
Master's of Science in Chemistry Graduate Program with specialty in Analytical Chemistry, Biochemistry, Inorganic Chemistry, Organic Chemistry, and Physical Chemistry.			Master's of Science in Chemistry Graduate Program with specialty in Analytical Chemistry Analytical Chemistry, Biochemistry, Inorganic Chemistry, Organic Chemistry, and Physical Chemistry.		
Core Courses			**Core Courses**		
Course Code	**Course Name**	**Credits**	**Course Code**	**Course Name**	**Credits**
CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3	CHEM 6000-8000	Chemistry Graduate Course at the 6000 or 8000 level	3
CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3	CHEM 6000-8000	Chemistry Graduate Course at the 6000 or 8000 level	3
CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3			
CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3			
	Total	*12*		*Total*	*6*

Elective Courses			**Elective Courses**		
Course Code	**Course Name**	**Credits**	**Course Code**	**Course Name**	**Credits**
CHEM 6000-8000	Elective Course	3	CHEM 6000-8000	Elective Course**	3
			CHEM 6000-8000	Elective Course**	3
			CHEM 6000-8000	Elective Course**	3
	Total	*3*		*Total*	*9*
Other Chemistry Courses			**Other Chemistry Courses**		
Course Code	**Course Name**	**Credits**	**Course Code**	**Course Name**	**Credits**
CHEM 8901	Graduate Seminar	1	CHEM 8901	Graduate Seminar	1
CHEM 8902	Graduate Seminar	1	CHEM 8902	Graduate Seminar	1
CHEM 6999/8999	Graduate Research	12	CHEM 6999	M.S. Thesis Research	6
CHEM 8000	Seminar in Chemistry	6	CHEM 8000	Focused Research Seminar	4
CHEM 6905	Principles and Practices	6	CHEM 8000	Scientific Writing Course	3
CHEM 6999	Laboratory Rotations	1	CHEM 6999	Laboratory Rotations	0
	Total	*27*		*Total*	*15*
Thesis Courses			**Thesis Courses**		
Course Code	**Course Name**	**Credits**	**Course Code**	**Course Name**	**Credits**
CHEM 6896	Thesis Continuation	0	CHEM 6896	Thesis Continuation	0
	Total	*0*		*Total*	*0*
	Total Number of Credits	***42***		***Total Number of Credits***	***30***

*See list of graduate courses in Appendix 1. There are five Chemistry Graduate Core Courses (two semester courses, therefore actually ten courses) at the 6000 level, one for each one of the core areas of Chemistry: Analytical (CHEM 6215/6225), Biochemistry (CHEM 6811/6812), Inorganic (CHEM 6011/6012), Organic (CHEM 6411/6412) and Physical Chemistry (CHEM 6611/6612). The CHEM 8999 course is the Research for the Doctoral Dissertation course, but it is being currently used as a one credit course for the rotation requirement for incoming new graduate students in the program. There are five Seminar in Chemistry courses at the 8000 level (two semester courses, therefore actually ten courses), one for each one of the core areas of Chemistry: Seminar in Analytical Chemistry (CHEM 8205/8206), Seminar in Biochemistry (CHEM 8801/8802), Seminar in Inorganic Chemistry (CHEM 8005/8006), Seminar in Organic Chemistry (CHEM 8405/8406) and Seminar in Physical Chemistry (CHEM 8605/8606). We propose to change the name of these courses to Focused Research Seminar in Chemistry, maintaining their current course codes.

** A student might take elective courses in areas other than Chemistry if in consultation with the advisor it is decided that taking that course(s) will help the student complete the thesis project.

Table 9 shows a comparative table of non-credit requirements for the current and proposed M.S. in Chemistry Program.

Table 9. Other Changes to Non-credit Requirements for the Proposed M.S. in Chemistry Program.

Current Non-credit Requirements		**Proposed Non-credit Requirements**	
Name	**Description**	**Name**	**Description**
Graduate Rotations	The students must participate of graduate rotation program during the first semester of their first year in the Program to explore research interest and dynamics of three different groups within the Chemistry Graduate Program. *Required.*	Graduate Rotations	The students will voluntarily enroll in the graduate rotation course to explore research interests and dynamics of three different groups within the Chemistry Graduate Program. *This is a zero credit course conducive to the degree*.
Qualifying Exams	Students are required to pass two (2) qualifying exams. The student must pass	Qualifying Exams	There will be no qualifying exams in the proposed revised M.S. program.

	one (1) qualifying exam in their area of specialty. *Required.*		
Proposal A	A research plan must be successfully depended in front of the student's Thesis Committee. This requirement also encompasses an oral exam in the student's area of specialty. *Required.*	(A) Research Plan Proposal and (B) Progress Report Meeting	(A) A research plan proposal must be successfully defended in front of the student's Thesis Committee by the end of their second (2^{nd}) semester of their (1st) first year in the program. This requirement also encompasses an oral exam in the student's area of specialty. (B) An oral presentation of the progress of the accomplished research plan will be performed during the course of the Master's no later than then third (3er) semester in the graduate program to the Thesis Committee Members. *Required.*
Oral Thesis Defense	Oral presentation of the Master's thesis. *Required.*	Masters thesis seminar and defense:	Oral presentation and defense of the Master's thesis in front of the Thesis Committee Members. *Required.*
CHEM 6905: Principles and Practices	Enroll in at least one academic year of CHEM 6905-6906 Principles and Practices of Chemistry. *Required.*	CHEM 6905: Principles and Practices	If necessary for financial assistance, the student may enroll in the course CHEM 6905-6906: Principles and Practices of Chemistry. *These credits will not be counted towards his/her degree. Not a requirement.*

5. **Syllabi of courses –** The syllabi of the courses for the revised M.S. in Chemistry Program remain the same as those of the current M.S. in. Chemistry program.

F. Admission, enrollment and graduation

1. **Admission requirements:** The applicant must have a bachelor's degree or its equivalent with an overall undergraduate grade point average of no less than 3.0 on a 4.0 scale and no less than 2.75 in chemistry. The applicant must have completed a one-year course in general chemistry, organic chemistry and physical chemistry, including laboratory work, and have at least one semester of analytical chemistry (including laboratory) and inorganic chemistry. The applicant must also have knowledge of mathematics through integral calculus, and one year of general physics. The applicant must have writing, reading, and conversational abilities in English given that courses are offered in this language (except in a course where all students are Spanish speakers, where the course in often given in Spanish).

2. **Application process:** To be considered for admission in August of the academic year, the applicant must fulfill and submit the application form located at the website: https://app.applyyourself.com/?id=upr-grad no later than December for international students and January for resident students. The applicant will be notified by e-mail from the Office of the Dean of Graduate Studies and Research regarding acceptance to the Program, no later than March for the international students and April for resident students.
    a. The applicant must submit three (3) official transcripts, which needs to include a degree certification at the following address: Graduate Programs and Research, University of Puerto Rico, Río Piedras Campus, 17 AVE Universidad STE 1701, San Juan PR 00925-2537, Physical address: Graduate Programs and Research, University of Puerto Rico, Río Piedras Campus, Natural Sciences Building, Phase II Room C-164, San Juan, Puerto Rico.
    b. In the application form the student must include two (2) e-mail addresses of professors that will recommend him/her, from the university where the applicant earned the bachelor's degree.
    c. The applicant must include a Statement of Purpose document indicating his/her interests in pursuing graduate studies.
    d. The applicant might be requested to attend a Personal interview (online or in person) with the Admissions Committee.
3. **Conditional admission:** An applicant who fails to fulfill one or more of the admission requirements, but who otherwise shows promise as a graduate student, may be granted conditional admission to the Graduate Program. To be considered for conditional admission it is required that the student has a general minimum grade point average of 2.75 and a 2.50 in chemistry. In this case, the applicant will be informed of the conditions that he or she must satisfy to be considered a regular bonafide student. Conditional admission means that the student will be on probation for a period of one year until he or she demonstrates academic progress. The Admission Committee will advise the student on the development of a class program that complies with these requirements. The Graduate Affairs Committee will determine if the student has fulfilled all conditions established by the Admission

Committee after the first year of study. A student who does not satisfy the admission conditions during the allotted time will be dropped from the Program.

4. **Enrollment projection –** Since we offer a Ph.D. in Chemistry Program where students with a B.S. in Chemistry do not have to obtain first a M.S. in Chemistry to obtain a Ph.D. degree (the standard in this academic field), the majority of students admitted to the program pursue directly the Ph.D. degree. Maybe one and occasionally two students per year inform that they are pursuing a M.S. degree in Chemistry, not a Ph.D. degree. However, the requirements to be classified as a Ph.D. candidate includes the approval of a candidacy exam. If a student that enrolled initially as one pursuing a Ph.D. degree does not pass the Ph.D. candidacy exam, the program reclassifies the student as a M.S. student and the student is required to complete a M.S. degree before applying for admission to the Ph.D. program to pursue a Ph.D. degree. A very few number of students per year are reclassified as M.S. students by this process. However, in the proposed revision of the Ph.D. in Chemistry Program (vide infra) when a student that is pursuing the Ph.D. degree passes the requirements equivalent to the M.S. degree, except the thesis, the program will confer the M.S. degree to this student. In addition, all students with a B.S. in Chemistry that enter the program and do not specify that they are pursuing a M.S. degree will be classified as Ph.D. students and if they do not pass the candidacy exam, then they will be reclassified as a M.S. student. Therefore, in summary, the projection of students that each year will enroll in the M.S. in Chemistry Program is around 1-4 students, but if the Ph.D. in Chemistry Program revision is approved, a larger number of students that the number of students in that year's cohort that initially enrolled as M.S. students will obtain the M.S. degree while pursuing the Ph.D. degree.

G. Faculty

The 15 professors that currently are part of the Chemistry Graduate Program faculty will be the professors that will participate in the proposed revised M.S. in Chemistry Program. The Department of Chemistry is currently recruiting an Organic Chemistry research professor and an Analytical Chemistry research professor. Both professors will also be part of the Chemistry Graduate Program faculty and will participate in the revised M.S. in Chemistry Program.

Table 10 list the professors currently in the Chemistry Graduate Program.

Table 10. List of Professors in the Chemistry Graduate Program

Names	Academic preparation (Ph.D.)	Teaching specialty	Lines of Research	Years of service
Carlos Cabrera	Cornell University, 1987	Analytical Chemistry, Nanotechnology	Nanomaterials for alkaline fuel cells. Dye sensitized solar cells. Microbial Fuel Cells. Nanobiosensors.	31
Néstor M. Carballeira	University of Würzburg, 1983	Medicinal Chemistry	Lipid Chemistry and Marine Natural Products: Isolation and Synthesis of New Fatty Acids of Marine Origin; New Antiplasmodial and Antifungal Lipids.	35
Zhongfang Chen	Nankai University, 2000	Thermodynamics Molecular Structure and Chemical Bonding	Computational chemistry, computational nanomaterials science, physical organic chemistry.	12
Jorge Colón	Texas A&M University, 1989	Inorgánic Chemistry, Chemistry of Materials, Bioinorganic Chemistry	Inorganic, bioinorganic, and materials chemistry; Layered inorganic compounds; Artificial photosynthesis; Amperometric biosensors; Drug delivery systems; Electrocatalysis of the OER reaction.	28
Kai Hans Griebenow	MIT, 1996 University of Duesseldorf, 1992	Advance Biochemistry	Structure-guided protein encapsulation, non-aqueous enzymology, protein formulation, protein stability, protein glycosylation, relationship between protein structural dynamics and enzyme activity, PEG modification of proteins, bio-fuel cells	24
Ingrid Montes	UPR-RP, 1985	Organic Chemistry	Organometallic chemistry Chemical education	33
Abimael D. Rodríguez	The Johns Hopkins University, 1983	Spectrometric Identification of Organics Compounds	Organic Chemistry: Isolation, Structure, Elucidation and Synthesis of Marine Natural Products.	33
Brad Weiner	University of California, 1986	Physical Chemistry	Physical Chemistry: Gas Phase Molecular Reaction Dynamics; Laser Photochemistry and Photophysics; Gas Phase Kinetics of Reactive Intermediates; Non-Linear Photoprocesses; Molecular Energy Transfer; Mechanisms of	32
Dalice M. Piñero	UPR-RP, 2009	Coordination Chemistry	Synthesis of metal complexes and multidimensional networks for their application in Materials Science and Nanomedicine.	6
Liz M. Díáz Vázquez	UPR-RP, 2005	Chemical Education, Renewable energy & Sustainability	Chemical Education, Renewable energy & Sustainability	15
Eduardo Nicolau	UPR-RP, 2012	Analytical applications of bio-nanomaterials	Preparation of interfaced bionanomaterials for reactive water purification membranes; Development of poin-of-use sensors for the detection of emerging contaminants in water; Synthesis and characterization of nanomaterials for electrooxidation of high-density fuels; Development of analytical methodology through chemometrics.	6
Vilmali López	University of Michigan-Ann Arbor. 2011.	Analytical Chemistry	Design of heteronucleation platforms for three major crystallization efforts: pure thermodynamically unstable solid-forms and/or pure enantiomers of pharmaceuticals, energetic materials, and electronic materials for novel applications. *Main Techniques and Instrumentation*, Powder and Single Crystal X-ray Diffraction, Raman, Infrared, and UV-Vis Spectroscopy, Quartz Crystal Microbalance (QCM-D), Microscopy, High Performance Liquid Chromatography (HPLC), Surface Analysis (AFM/SEM) and Thermal Analysis (TGA/DSC).	6
José A. Rivera	MIT, 2000	Organic Chemistry	Supramolecular chemistry, molecular recognition, organic synthesis, nanotechnology, bioorganic chemistry, medicinal chemistry.	18
Arthur D. Tinoco	Yale University, 2007	Inorganic and Bioinorganic Chemistry	Bioinorganic Chemistry, Proteomics, Anticancer research, Metal-based	8
Marvin Bayro	MIT, 2010	Physical Chemistry, Biophysics	Protein Structure and Dynamics, Solid-state NMR Spectroscopy, Biophysical Chemistry, Protein Assemblies,	4

H. Administration of the Program

The Coordinator of the Chemistry Graduate Program currently administers the M.S. and Ph.D. in Chemistry programs and will administer the proposed revised M.S. in Chemistry program. An administrative assistant from the Office of Graduate Studies and Research of the College of Natural Sciences is assigned to provide administrative assistance to all programs in the Chemistry Graduate Program and will continue to do so for the proposed revised M.S. in Chemistry Program. The Chemistry Graduate Program has an Admissions Committee, and Graduate Affairs Committee, a Curriculum Committee, an Academic Affairs Committee, and a Student Learning Assessment Committee.

I. Information resources

Students and professor in the Chemistry Graduate Program have access to hundreds of chemistry journals and books through the College of Natural Sciences Library. The University of Puerto Rico has a contract with the American Chemical Society (ACS) that gives free access to papers in the dozens of journals that ACS publishes. In addition, SciFinder is also provided. SciFinder, produced by Chemical Abstracts Service (CAS), a Division of the American Chemical Society, is the most comprehensive database for the chemical literature, searchable by topic, author, substances by name or CAS Registry Number, or by the use of the editor to draw chemical structures, substructures, or reactions.

The Program, through the Néstor Rodríguez Rivera Library of the College of Natural Sciences, has access to 1,730 bibliographic resources whose specific subject is Chemistry and 2,996 bibliographic resources whose general subject is related to chemistry. In addition, we have 450 journals in Chemistry and a total of 5,260 journals in the Sciences. There is also access to the Directory of Open Access Journals (DOAJ) which has 377 journals in Chemistry. On the other hand, the Library System catalog provides access to the Catalog of the Medical Sciences Campus with 375 general bibliographic resources in Chemistry and to the Mayagüez Campus catalog with 2,900 bibliographic resources whose specific subject is Chemistry. In electronic resources we have had 16 databases altogether, but the total per year fluctuates between 8 and 11. Among those bibliographic resources are those of ACS Publications, Annual Reviews,

Elsevier, SciFinder, Springer, Web of Science and Wiley. The most recently acquired electronic resources are Annual Reviews, Cambridge University Press, Chicago University Press, Institute of Physics, Oxford Unviersity Press, SAGE, SciFinder, SIAM, Springer, Taylor & Francis and Wiley.

J. Teaching, research and service infrastructure

The Chemistry Graduate program has one assigned classroom available at the Facundo Bueso building (FB-266), but also has access to classrooms in the College of Natural Sciences building. The research laboratories are located in three different buildings: the Facundo Bueso building, the building of the College of Natural Sciences and the off-campus Molecular Sciences Research Center. The Molecular Sciences Research Center has one of the most advance scientific instrumentation facilities in the Caribbean. All laboratories have a current Chemistry Hygiene and Safety Plan and the professors have the required explosives license from the Puerto Rico Police Department.

K. Student services

1. **Student services and support systems:** Apart from the student services obtained from the Coordinator of the Chemistry Graduate Program, all other student services are provided through the Office of Graduate Studies and Research of the College of Natural Sciences (CNS) and the Office of the Department of Chemistry, both located in the CNS building, as well as the Deanship of Graduate Studies and Research and the different campus-wide offices such as Deanship of Academic Affairs, Deanship of Students, Registrar Office, Students' Ombusperson, Medical Services Facilities, and the Department of Counseling for the Student Development (DCODE), among others. Those services include admissions, enrollment, economic assistance, medical services, professional counseling and psychological services, and library services, among others.
2. **Economic assistance** – Students in the program are eligible to the Formative Academic Experience Program (PEAF) of the Deanship of Graduate Studies and Research, which provides stipends of $810 monthly for M.S. students for 10 months of the academic year. Students are also eligible to fellowships offered by the Deanship of Graduate Studies and Research and federal programs sponsored by NSF, NIH, NASA, DOE, some of the through programs on campus that opened thanks to

successful grant applications to those federal agencies. Some of those program are the Puerto Rico Louis Stokes Alliance for Minority Participation Bridge to the Doctorate Fellowship (PR-LSAMP), the Puerto Rico Space Partnership for Research Innovation and Training PR-SPRInT), the NSF-PREM Center for Interfacial Electrochemistry of Energy Materials (CIE^2M), the NSF-CREST Center for Innovation, Research and Education in Environmental Nanotechnology ($CIRE^2N$), and the Research Training Initiative for Student Enhancement (RISE) Program.

L. Catalog and promotion

The program is promoted with a flyer of the Chemistry Graduate Program, that campus webpages, the Department of Chemistry webpages, and the Facebook pages of the Department of Chemistry and the College of Natural Science, plus the Twitter page of the College of Natural Sciences. The Catalog of courses for the M.S. in Chemistry Program is currently available to all interested students in the webpage of the Deanship of Graduate Studies and Research.

M. Budget Plan

Currently the Chemistry Graduate Program has no budget assigned to it in the annual budget of the Department of Chemistry or the College of Natural Sciences. All expenses to run the program are covered by the Department of Chemistry budget. A line item in the Department of Chemistry budget for travel is reserved for use by the Chemistry Graduate Program to cover the travel expenses of the speakers invited to participate in our Graduate Seminar Series. We would also like also for the line item in the Department of Chemistry budget for solvents, dry ice, gas tanks and liquid nitrogen be reserved for use by Chemistry Graduate Program.

The most recent self-study of the current M.S. and Ph.D. programs, which covered the academic years 2009-2010 to 2014-2015, described the lack of a separate budget for the Chemistry Graduate Program as a weakness of the program. Five years later, this is still the case. The program is embarked right now in a new self-study that will cover the period 2015-2016 to 2019-2020 and it will describe that this weakness remains.

Since all funds needed to run the program come out of the assigned budget to the Department of Chemistry, **this proposal for revision of the M.S. program will have no budget impact**.

N. Assessment of the program and Student Learning Assessment Plan

1. **Development Plan** - The Chemistry Graduate Program has a five-year development plan submitted in 2016 that will be updated this year as part of the response to the self-study evaluation of the program currently underway. Every five years we administer a questionnaire to current students, alumni and professors of the program. The information obtained is used to assess the current program and propose any necessary changes. Part of the justification to embark in the preparation of this proposal was the results of the last questionnaire from 2015-2016.

   The next five-year development plan due in September 2021 will include ways to assess the implementation of the approved revisions of the M.S. and Ph.D. programs and the establishment of the new M.A. program.

2. **Student Learning Assessment Plan**

   The Student Learning Assessment Plan of the Chemistry Graduate Program is based on the development of established learning domains for all students on campus, which includes the graduate students in our current programs (M.S. and Ph.D.). The development of those learning domains among the students in these programs will allow them, at the end of their graduate studies, to fulfill the new alumnus profile (Appendix 2a). The assessment plan uses an evaluation model of the UPR Division of Institutional Research and Assessment (DIRA) of the Deanship of Academic Affairs. The assessment is based on certain learning domains with their learning objectives and the courses where they will be evaluated to access student learning in each of those domains. In the first semester of the 2019-2020 Academic Year the program submitted the required three-year and annual plans (see tables of the three-year plan and the Annual Assessment Plan submitted and approved by the DIRA). These tables will be used as part of the Assessment Plan for the proposed revised M.S. program. We will use the online OLAS system for these assessments. The annual reports will be shared with the entire Program's faculty and an action plan will be established to correct identified problem areas. The student learning assessment information will be used to assess how the program is fulfilling its student learning goals as well as the graduate program development goals. Table 21 shows a summary

of the three-year plan, which is presented in Table 22. Table 23 is the annual assessment plan.

VII. Description of the proposed new Master's of Arts in Chemistry (M.A.) Program (no thesis)

We propose to establish a new M.A. in Chemistry program (no thesis) following the recommendation of Certification No. 95, 2019-2020, of the Academic Senate, which suggests that Master's programs on campus should offer a non-thesis option. In addition, there is high demand of Master's programs in Chemistry with no thesis requirement, particularly for professionals with a B.S. degree currently employed in industry or government.[1]

A. General description of the proposed new M.A. in Chemistry program

1. **Title of the Program and Degree to be awarded:** The new M.A. in Chemistry Program will be part of the **Chemistry Graduate Program** and will lead to M.A. in Chemistry degree with a subspecialty in Analytical Chemistry, Biochemistry, Inorganic Chemistry, Organic Chemistry or Physical Chemistry.
2. **Description of the program (Summary of the revised M.A. in Chemistry Program components):** The new M.A. in Chemistry Program will consist of 30 credits to be in compliance with Certification No. 95 of the Academic Senate, 2019-2020 Academic Year (Academic Policy for Graduate Studies of the Río Piedras campus). The M.A. in Chemistry requirements are tabulated at the end of this section. No thesis is required to obtain the M.A. in Chemistry degree, but the research requirement required by Certification No. 95 will be fulfilled with a Research Review Paper and Presentation.
3. **Program modalities:** The M.A. in Chemistry will be obtained through a combination of "in person" teaching, training and learning, and other non-traditional teaching/learning strategies, including hybrid and online distance education.
4. **Starting date of the revised M. A. in Chemistry program:** Academic Year 2021-2022.
5. **Duration of the revised M.A. in Chemistry program:** The expected duration of the program for full-time students will be <u>one and a half (1 1/2) years</u> and for part-

time students will be three (3) years. The maximum time to complete the program for full-time students will be four (4) years and for part-time students will be 5 years.

B. Professional accreditation

Although our campus' B.S. in Chemistry program is accredited by a professional association, the American Chemical Society (ACS), this professional organization does not accredits graduate programs in Chemistry. Therefore, our Master's and Ph.D. programs. are not eligible for accreditation from a professional association. By law, chemists in Puerto Rico working outside of academia but possess at least a B.S. in Chemistry degree and be licensed to practice the profession by the Chemists Examining Board of the Department of State of Puerto Rico.

C. Relation of the academic program with the current mission and Strategic Plan of the UPR and the Río Piedras Campus

The proposed new M.A. in Chemistry Program is aligned with the current Mission and Strategic Plan 2017-2022 of the University of Puerto Rico (Certificate No. 50, 2016-2017, of the Governing Board) and with the Strategic Plan 2018-2023 of the Río Piedras Campus (Certificate No. 79, 2017-2018, of the Academic Senate). The program emphasizes (a) to achieve and maintain excellence in education, research and dissemination of knowledge, (b) a commitment to the integral formation of the student and his lifelong learning; (c) the dissemination of knowledge at the national and international level and (d)to contribute to the scientific, social and economic development of the country to improve the quality of life in Puerto Rico, the Caribbean and the world.

The Program is consistent with the Mission of the Río Piedras Campus in terms of providing graduate education of the highest quality that develops capacities for independent study and research and helps strengthen undergraduate education. In addition, in the training of professionals of the highest caliber, committed to the ideals and values of Puerto Rican society. Likewise, to develop teaching, research and development, and the dissemination of knowledge at an international level.

D. Conceptual Framework

1. **Vision:** We aim to develop lifelong learning, creation and dissemination of knowledge at national and international level and the training of professionals of

chemistry that promote scientific, social, and economic development, to improve the quality of life in Puerto Rico, the Caribbean, and the world.

2. **Mission:** The mission of the M.A. program of the Chemistry Graduate Program is to educate and train professionals with knowledge in the fundamentals of chemistry, while providing an enabling experience in a specific area belonging to one of the classic branches (Analytical Chemistry, Biochemistry, Inorganic Chemistry, Organic Chemistry, Physical Chemistry) or emerging interdisciplinary branches such as materials science, bioinorganic chemistry, supramolecular chemistry and nanotechnology, among others. The preparation of professionals in chemistry at an advanced level also seeks to develop in them the importance of creating a safe environment in the work area, the ability to identify major problems in the discipline and to design effective strategies for solving them by encouraging good laboratory practices, interdisciplinarity and collaboration at the departmental, national, and international level. In a broader context, the mission of the Graduate Program is to prepare professionals to practice their profession with the firm intention of advancing knowledge in chemistry, bringing this knowledge to solve problems of daily life and human welfare while instilling in our students hard and soft skills sets that will directly prepare them for post-graduate work and to promote scientific, social, and economic development to improve the quality of life in Puerto Rico, the Caribbean, and the world.
3. **Goals and Objectives:** The Chemistry Graduate Program is the product of an urgent need to create the intellectual resources needed to make Puerto Rico an attractive place for the development of new technologies and enterprises with capable personnel, who have the capacity of adapting to the changing paradigm of science and technology entrepreneurship while promoting scientific, social, and economic development in Puerto Rico, the Caribbean, and the world. The objectives of the program are:
    a. To provide the basic theoretical-practical knowledge required to perform as a competent professional in the area of chemistry
    b. To encourage scientific, creative and critical research, framed in the ethical - professional commitment.

c. To contribute to the solution of issues and problems related to Chemistry and the sciences, arts and industries related to it.
d. To advance the knowledge of Chemistry and ensure human well-being by providing ideas for solving problems in society beyond the research laboratory.
e. To link the University with the world reality to improve the well-being of the human being.
f. To contribute to the improvement of undergraduate programs through research opportunities, exchange of ideas and activities with graduate studies.
g. To offer chemical advice to the community, the country's educational system, the government, and industries.
h. To identify institutional and external funds to provide a physical and administrative infrastructure that allows sustaining and optimizing the operation of the program to efficiently serve a heterogeneous audience of students and professionals.

4. **Philosophy:** Both the Chemistry Department at UPR-RP and its Chemistry Graduate Program are dedicated to serve Puerto Rico by developing professionals capable of contributing to the scientific, technological, and socio-economic growth of Puerto Rico and the world.
5. **Proposed new M.A. in Chemistry Program alumnus profile (in compliance with the Graduate Student Alumnus Profile of the Río Piedras Campus – Certification No. 104, 2016-2017 Academic Year, of the Academic Senate, see Appendix 2):** At the end of their graduate studies, students are expected:
   a. To conduct creative, critical and innovative scientific research to offer solutions and generate knowledge framed in an ethical-professional commitment as learned through problem solving based learning strategies in the program.
   b. To know and critically evaluate the scientific literature and methodology and use the obtained information in problem solving.
   c. To exercise independence of opinion and show creativity and initiative to contribute to the solution of matters and problems related to Chemistry and the sciences, arts, and enterprises related to it.

d. To integrate theories and practical protocols that protect the environment and ethical and security codes in his/her professional and research endeavors.
e. To know the scientific literature and manage information in a critical, effective and ethical way for problem solving.
f. To incorporate current instrumentation and technological resources as resource tools in the design of experiments and in problem solving.
g. To communicate effectively the fundamentals of his/her discipline to the scientific community and to diverse groups in a clear and logical manner.
h. To show commitment with the protection of natural, environmental, and cultural resources through Chemistry best practices and the occupational safety and environmental protection norms.
i. To show respect to human rights through actions of social inclusiveness and commitment to diversity.
j. To demonstrate collaborative research actions through multi-, inter-, and transdisciplinary teamwork.
k. To assume and encourage leadership roles that contribute to individual and collective transformations.
l. To master the fundamental concepts of Chemistry, of its diverse applications in daily life and its relationship with other scientific disciplines.
m. To identify important problems inherent to Chemistry and other disciplines to design effective strategies and/or experiments for their solution.
n. To show capacity to apply chemical knowledge, skills, and ethical conduct in the solution of real problems associated with the Chemistry field that promote scientific, social, and economic development to improve the quality of life in Puerto Rico, the Caribbean and the world.

6. **Coherence and sufficiency:** The components of the conceptual framework are coherent and sufficient and meet the conditions to provide the necessary structure to the proposed program. The harmony and logical and consequent relationship between the Mission, Goals, Objectives, and the Alumnus Profile allows the program to successfully continue to pursue its Vision.

E. Curricular design (proposed revised graduation requirements)

1. **General requirement:** The new M.A. in Chemistry Program candidates must comply with the general graduation requirements that are mandated by the UPR-RP Campus.
2. **Curriculum Requirements (Table 11):**
   a. **Course Work: –** Complete a minimum of **twenty four (24)** credits in graduate courses. The M. A. graduate student must consult with the Graduate Program Coordinator each year about which courses to take prior to enrollment. The Graduate Program Coordinator might recommend the student to take courses in another discipline, for example, Biology, Physics, Environmental Sciences or Mathematics when these courses are deemed necessary for the student's development as an independent researcher.
      i. **Nine (9) credits of 6000-8000 level graduate chemistry courses.**
      ii. **Fifteen (15) credits in graduate level electives** at a 6000-8000 level. Including a Scientific Writing Course described below.
      (See list of courses in Appendix 1).
   b. **Graduate Seminars:** The student must enroll and attend the graduate seminar course (QUIM 8901-8902) every academic year. The student needs to approve a minimum of three (3) credits. In the final semester taking this graduate seminar course, the student will present the Research Review Paper and defend it as the final requirement of the M.A. degree.
   c. **Scientific Writing Course:** Enroll in a three (3)-credit scientific writing course. The course will serve to introduce scientific writing tools and methods, as well as develop the student's capabilities to adequately develop a Research Review Paper and Presentation to complete the requirement of the Certification No. 95 for non-thesis Master's degrees. The students will take this course during the first semester of the second year in the Graduate Program.
3. **Additional requirements:**
   a. **Placement Exams:** Upon acceptance into the Chemistry Graduate Program, students will be required to take an entrance placement exam to demonstrate basic knowledge in each of these areas: Analytical, Biochemistry, Inorganic, Organic, and Physical Chemistry**.** The results of the placement exam will be shared with

all professors of the Chemistry Graduate Program so that each division can assess how to help the student reach the academic standards that are expected for every graduate in the Chemistry Graduate Program. In addition, the results will be used to help develop the first annual Individualized Development Plan (IDP) for the student in conjunction with the division(s) and/or the Program Coordinator. The final IDP should be submitted and approved by the Graduate Affairs Committee. An annual IDP will be required for all graduate students in a format similar to the ChemIDP of the American Chemical Society (https:chemidp.acs.org) or the MyIDP of the American Association for the Advancement of Science (http://myidp.sciencecareers.org) throughout every year of the program.

b. **GPA requirements and optional candidacy exam:** Students must earn at least a **C** in each course and an overall GPA of 3.0 at the completion of the first year of courses to be in good standing and qualify to take the Ph.D. candidacy exam if the student wishes to transfer to the Ph.D. program. Students who earn more than a 2.5 but below 3.0 GPA and wish to transfer to the Ph.D. program will be allowed to take the first year Ph.D. candidacy exam but must repeat the course with the deficiency to raise their GPA to 3.0 upon completion of the second year. Students who earn less than a 3.0 GPA will be dropped from the program after the allotted probation period. If a student earns a GPA above 3.5 (with two A's in their area of specialty) and wishes to transfer to the Ph.D. program, the student will be exempt from the mandatory Ph.D. candidacy exam. The minimum GPA for graduation will be of 3.0 in a scale of 4.0. A student that falls below a 3.0 GPA will be in a probation period of one (1) year if the student entered as a regular student, and a probation period of one (1) semester if the student entered the Program conditionally. During the probation period research or teaching assistantships might not be available. Students that are not in good standing after the allotted academic probation period will be dropped from the Graduate Program.

c. **Public speaking workshop:** A public speaking workshop will be offered to all graduate students once a year.

Table 11 shows a summary of the proposed new M.A. in Chemistry Program requirements.

Table 11. Summary of the Proposed New M.A. in Chemistry Program Requirements.

Summary of the Existing Doctoral Program Requirements	Credits
Chemistry Graduate Core Courses (6000 level)	15
Free Electives Courses (6000 level)/(8000 level)	9
Scientific Writing Course	3
Graduate Seminars	3
Research Review Paper and Presentation	0
Total credits	***30***

4. Proposed course sequence of the new M.A. in Chemistry Program

Table 12 shows the proposed course sequence for full-time students enrolled in the new M.A. in Chemistry Program.

Table 12. Proposed Course Sequence for **full-time students** enrolled in the new M.A. in Chemistry Program.*

First Year					
First Semester			**Second Semester**		
Course Code	**Description**	**Credits**	**Course Code**	**Description**	**Credits**
CHEM 6905	Principles and Practices	3**	CHEM 6905	Principles and Practices	3**
CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3	CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3
CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3	CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3
CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3	CHEM 6000	Elective Course***	3
CHEM 8999	Laboratory Rotations	0	CHEM 8902	Graduate Seminar	1
	Total	*9/12***		*Total*	*10/13**)*
First Summer					
Third Semester			**Fourth Semester**		
Course Code	**Course Name**	**Credits**	**Course Code**	**Course Name**	**Credits**
CHEM 6905	Principles and Practices	3**	CHEM 6905	Principles and Practices	3**
CHEM 8000	Scientific Writing Course	3			
CHEM 8000	Elective Course***	3			
CHEM 8000	Elective Course***	3			
CHEM 8901	Graduate Seminar	1	CHEM 8902	Graduate Seminar	1
			Milestone: Research Review Paper Presentation and Defense 0 credit		
	Total	*10/13***		*Total*	*1/4***

*See list of graduate courses in Appendix 1. There are five Chemistry Graduate Core Courses (two semester courses, therefore actually ten courses) at the 6000 level, one for each one of the core areas of Chemistry: Analytical (CHEM 6215/6225), Biochemistry (CHEM 6811/6812), Inorganic (CHEM 6011/6012), Organic (CHEM 6411/6412) and Physical Chemistry (CHEM 6611/6612). The CHEM 8999 course is the Research for the Doctoral Dissertation course, but it is being currently used as a one credit course for the rotation requirement for incoming new graduate students in the program.
** For students that due to financial reasons, need to continue being teaching assistants. TA is not a requirement for Master's of Science students.
*** A student might take elective courses in areas other than Chemistry if in consultation with the advisor it is decided that taking that course(s) will help the student complete the thesis project.

The Chemistry Graduate Program offers courses in five areas of Chemistry: Analytical Chemistry, Biochemistry, Physical Chemistry, Inorganic Chemistry, and Organic Chemistry. During the first year in the program, students can take two core courses in two of these five areas. In later years, students can take elective/advanced courses in their area of specialty, as well as elective courses from any other area (even from areas outside the Program, say courses from the Graduate Program in Biology, or Physics or Environmental Sciences, depending if the student and his/her mentor determine it is necessary to assist the student in their master's thesis or doctoral dissertation work). Core courses from the other areas that the student did not take courses in their first year in the program may be taken by these students as elective courses. All those courses currently have a code. For this reason, currently there is no elective course that is in the process of obtaining a code. Furthermore, there are advanced 8000 level courses called Special Topics Course for each of the five areas. In each area, with the same code, different courses of this type can be offered, just by changing the course title (for example, QUIM 8990-Special Topics in Inorganic Chemistry - Bioinorganic Chemistry and QUIM 8990-Special Topics in Inorganic Chemistry - Crystallography). These are state-of-the-art courses are offered on the latest and greatest issues in the area of Chemistry. Some of these courses have been offered for several years and there is interest in their conversion to separate courses with separate codes. But for this proposal for the revision of the M.S. and Ph.D. Chemistry programs and the establishment of the new M.A. in Chemistry program, we do not need to already have a code for those course since they are already being currently offered within a course with a code and can be taken as electives right now.

Table 13 shows the proposed course sequence for part-time students enrolled in the M.A. in Chemistry program.

Table 13. Proposed Course Sequence for **part-time students** enrolled in the M.A. in Chemistry Program.*

First Year					
First Semester			**Second Semester**		
Course Code	**Description**	**Credits**	**Course Code**	**Description**	**Credits**
CHEM 6905	Principles and Practices	3**	CHEM 6905	Principles and Practices	3**
CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3	CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3
CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3	CHEM 6000-8000	Elective Course***	3
	Total	*6/9***		*Total*	*6/9***
First Summer					
Second Year					
Third Semester			**Fourth Semester**		

Course Code	Course Name	Credits	Course Code	Course Name	Credits
CHEM 6905	Principles and Practices	3	CHEM 6905	Principles and Practices	3
CHEM 6000-8000	Chemistry Graduate Course	3	CHEM 6000-8000	Chemistry Graduate Course	3
CHEM 8000	Scientific Writing Course	3	CHEM 6000-8000	Elective Course***	3
CHEM 8901	Graduate Seminar	1	CHEM 8902	Graduate Seminar	1
	Total	*7/10***		*Total*	*7/10***
Third Year					
Fifth Semester			**Six Semester**		
Course Code	**Course Name**	**Credits**	**Course Code**	**Course Name**	**Credits**
CHEM 6905	Principles and Practices	3*	CHEM 6905	Principles and Practices	3*
CHEM 6000-8000	Elective Course***	3	CHEM 8902	Graduate Seminar	1
			Milestone: Research Review Paper Presentation and Defense 0 credit		
	Total	*3/6*		*Total*	*1/4*

*See list of graduate courses in Appendix 1. There are five Chemistry Graduate Core Courses (two semester courses, therefore actually ten courses) at the 6000 level, one for each one of the core areas of Chemistry: Analytical (CHEM 6215/6225), Biochemistry (CHEM 6811/6812), Inorganic (CHEM 6011/6012), Organic (CHEM 6411/6412) and Physical Chemistry (CHEM 6611/6612). The CHEM 8999 course is the Research for the Doctoral Dissertation course, but it is being currently used as a one credit course for the rotation requirement for incoming new graduate students in the program.

** For students that due to financial reasons, need to continue being teaching assistants. TA is not a requirement for Master's of Arts students.

*** A student might take elective courses in areas other than Chemistry if in consultation with the advisor it is decided that taking that course(s) will help the student complete the thesis project.

Table 14 shows the proposed curriculum in the new M.A. in Chemistry Program.

Table 14. Table of Proposed Curriculum in the new Master's in Arts in Chemistry Program.

Proposed Curriculum (M.A. in Chemistry Program)		
Master's of Arts in Chemistry Program with specialty in Analytical Chemistry, Biochemistry, Inorganic Chemistry, Organic Chemistry, or Physical Chemistry.		
Core Courses		
Course Code	**Course Name**	**Credits**
CHEM 6000-8000	Chemistry Graduate Course	3
CHEM 6000-8000	Chemistry Graduate Course	3
CHEM 6000-8000	Chemistry Graduate Course	3
CHEM 6000-8000	Chemistry Graduate Course	3
CHEM 6000-8000	Chemistry Graduate Course	3
	Total	*15*
Elective Courses		
Course Code	**Course Name**	**Credits**
CHEM 6000-8000	Elective Course*	3
CHEM 6000-8000	Elective Course*	3
CHEM 6000-8000	Elective Course*	3
	Total	*9*
Other Chemistry Courses		
Course Code	**Course Name**	**Credits**
CHEM 8901	Graduate Seminar	1
CHEM 8902	Graduate Seminar	1

CHEM 8902	Graduate Seminar (for presentation of Research Review Paper and Defense which constitute the final Milestone of the M.A. degree)	1
CHEM 8000	Scientific Writing Course	3
	Total	*6*
Other Requirement		
Milestone: Research Review Paper and Presentation		0
	Total Number of Credits	***30***

* A student might take elective courses in areas other than Chemistry if in consultation with the advisor it is decided that taking that course(s) will help the student complete the thesis project.

Table 15 shows a comparative table of non-credit requirements for the proposed new M.A. in Chemistry Program.

Table 15. Other Non-credit Requirements for the new M.A. in Chemistry Program.

Proposed Non-credit Requirements	
Name	**Description**
CHEM 6905: Principles and Practices	If necessary for financial assistance, the student may enroll in the course CHEM 6905-6906: Principles and Practices of Chemistry. *These credits will not be counted towards his/her degree. Not a requirement.*
Research Review Paper and Presentation	On the last semester in the program the student will submit and present to the Chemistry Graduate Program as part of the Chemistry Graduate Seminar Series a Research Review Paper and Presentation to fulfill the research experience requirement for Master's degree specified in the Certification No. 95.

5. **Syllabi of courses –** The syllabi of the courses for the new M.A. in Chemistry Program will be the same as those of the current M.S. in. Chemistry program.

F. Admission, enrollment and graduation

1. **Admission requirements:** The applicant must have a bachelor's degree or its equivalent with an overall undergraduate grade point average of no less than 3.00 and no less than 2.75 in chemistry. The applicant must have completed a one-year course in general chemistry, organic chemistry and physical chemistry, including laboratory work, and have at least one semester of analytical chemistry (including laboratory) and inorganic chemistry. The applicant must also have knowledge of mathematics through integral calculus, and one year of general physics. The applicant must have writing, reading, and conversational abilities in English given that courses are offered in this language (except in a course where all students are Spanish speakers, where the course in often given in Spanish).

2. **Application process:** To be considered for admission in August of the academic year, the applicant must fulfill and submit the application form located at the website: https://app.applyyourself.com/?id=upr-grad no later than December for international students and January for resident students. The applicant will be notified by e-mail from the Office of the Dean of Graduate Studies and Research regarding acceptance to the Program, no later than March for the international students and April for resident students.
    a. The applicant must submit two (2) official transcripts, which needs to include a degree certification at the following address: Graduate Programs and Research, University of Puerto Rico, Río Piedras Campus, 17 AVE Universidad STE 1701, San Juan PR 00925-2537, Physical address: Graduate Programs and Research, University of Puerto Rico, Río Piedras Campus, Natural Sciences Building, Phase II Room C-164, San Juan, Puerto Rico.
    b. In the application form the student must include two (2) e-mail addresses of professors that will recommend him/her, from the university where the applicant earned the bachelor's degree.
    c. The applicant must include a Statement of Purpose document indicating his/her interests in pursuing graduate studies.
    d. The applicant might be requested to attend a Personal interview (online or in person) with the Admissions Committee.
3. **Conditional admission:** An applicant who fails to fulfill one or more of the admission requirements, but who otherwise shows promise as a graduate student, may be granted conditional admission to the Graduate Program. To be considered for conditional admission it is required that the student has a general minimum grade point average of 2.75 and a 2.50 in chemistry. In this case, the applicant will be informed of the conditions that he or she must satisfy to be considered a regular bonafide student. Conditional admission means that the student will be on probation for a period of one year until he or she demonstrates academic progress. The Admission Committee will advise the student on the development of a class program that complies with these requirements. The Graduate Affairs Committee will determine if the student has fulfilled all conditions established by the

Admission Committee after the first year of study. A student who does not satisfy the admission conditions during the allotted time will be dropped from the Program.

4. **Enrollment projection –** Since we offer a Ph.D. in Chemistry Program where students with a B.S. in Chemistry do not have to obtain first a M.A. or a M.S. in Chemistry to obtain a Ph.D. degree (the standard in this academic field), the majority of students admitted to the program pursue directly the Ph.D. degree. Maybe one and occasionally two students per year inform that they are pursuing a M.S. degree in Chemistry, not a Ph.D. degree. However, concerning this new M.A. Program, we believe based on the expected demand on the island, particular from professionals currently working as licensed chemists in industry and government, that we can project that the number of students that each year will enroll in the M.A. in Chemistry Program will be around 3-5 students for the initial 5-year period, with a projection to increase that number to 5-10 students for the second 5-year period.

   Is important to indicate that the requirements to be classified as a Ph.D. candidate includes the approval of a candidacy exam. If a student that enrolled initially as one pursuing a Ph.D. degree does not pass the Ph.D. candidacy exam, the program reclassifies the student as a M.S. student and is required to complete a M.S. degree before applying for admission to the Ph.D. program to pursue a Ph.D. degree. A very few students per year are reclassified as M.S. students by this process. We expect that some of these students might decide and ask to be classified as a M.A. student and complete the requirements to the M.A. instead of the M.S.

G. Faculty

The 15 professors that currently are part of the Chemistry Graduate Program faculty (vide supra, Table 10) will be the professors that will participate in the proposed new M.A. in Chemistry Program. The Department of Chemistry is currently recruiting an Organic Chemistry research professor and an Analytical Chemistry research professor. Both professors will also be part of the Chemistry Graduate Program faculty and will participate in the new M.A. in Chemistry Program.

H. Administration of the Program

The Coordinator of the Chemistry Graduate Program currently administers the M.S. and Ph.D. in Chemistry programs and will administer the proposed new M.A. in Chemistry program. An administrative assistant from the Office of Graduate Studies and Research of the College of Natural Sciences is assigned to provide administrative assistance to all programs in the Chemistry Graduate Program and will continue to do so for the new M.A. in Chemistry Program. The Chemistry Graduate Program has an Admissions Committee, and Graduate Affairs Committee, a Curriculum Committee, an Academic Affairs Committee, and a Student Learning Assessment Committee.

I. Information resources

Students and professor in the Chemistry Graduate Program have access to hundreds of chemistry journals and books through the College of Natural Sciences Library. The University of Puerto Rico has a contract with the American Chemical Society (ACS) that gives free access to papers in the dozens of journals that ACS publishes. In addition, SciFinder is also provided. SciFinder, produced by Chemical Abstracts Service (CAS), a Division of the American Chemical Society, is the most comprehensive database for the chemical literature, searchable by topic, author, substances by name or CAS Registry Number, or by the use of the editor to draw chemical structures, substructures, or reactions.

The Program, through the Néstor Rodríguez Rivera Library of the College of Natural Sciences, has access to 1,730 bibliographic resources whose specific subject is Chemistry and 2,996 bibliographic resources whose general subject is related to chemistry. In addition, we have 450 journals in Chemistry and a total of 5,260 journals in the Sciences. There is also access to the Directory of Open Access Journals (DOAJ) which has 377 journals in Chemistry. On the other hand, the Library System catalog provides access to the Catalog of the Medical Sciences Campus with 375 general bibliographic resources in Chemistry and to the Mayagüez Campus catalog with 2,900 bibliographic resources whose specific subject is Chemistry. In electronic resources we have had 16 databases altogether, but the total per year fluctuates between 8 and 11. Among those bibliographic resources are those of ACS Publications, Annual Reviews, Elsevier, SciFinder, Springer, Web of Science and Wiley. The most recently acquired

electronic resources are Annual Reviews, Cambridge University Press, Chicago University Press, Institute of Physics, Oxford Unviersity Press, SAGE, SciFinder, SIAM, Springer, Taylor & Francis and Wiley.

J. Teaching, research and service infrastructure

The Chemistry Graduate program has one assigned classroom available at the Facundo Bueso building (FB-266), but also has access to classroom in the College of Natural Sciences building. The research laboratories are located in three different building: the Facundo Bueso building, the building of the College of Natural Sciences and the off-campus Molecular Sciences Research Center. The Molecular Sciences Research Center has one of the most advance scientific instrumentation facilities in the Caribbean. All laboratories have a current Chemistry Hygiene and Safety Plan and the professors have the required explosives license from the Puerto Rico Police Department.

K. Student services

1. Student services and support systems: Apart from the student services obtained from the Coordinator of the Chemistry Graduate Program, all other student services are provided through the Office of Graduate Studies and Research of the College of Natural Sciences (CNS) and the Office of the Department of Chemistry, both located in the CNS building, as well as the Deanship of Graduate Studies and Research and the different campus-wide offices such as Deanship of Academic Affairs, Deanship of Students, Registrar Office, Students' Ombusperson, Medical Services Facilities, and the Department of Counseling for the Student Development (DCODE), among others. Those services include admissions, enrollment, economic assistance, medical services, professional counseling and psychological services, and library services, among others.
2. Economic assistance – Students in the program are eligible to the Formative Academic Experience Program (PEAF) of the Deanship of Graduate Studies and Research, which provides stipends of $810 monthly for Master's. students for 10 months of the academic year. Students are also eligible to fellowships offered by the Deanship of Graduate Studies and Research and federal programs sponsored by NSF, NIH, NASA, DOE, some of the through

programs on campus that opened thanks to successful grant applications to those federal agencies. Some of those programs are the Puerto Rico Louis Stokes Alliance for Minority Participation Bridge to the Doctorate Fellowship (PR-LSAMP), the Puerto Rico Space Partnership for Research Innovation and Training PR-SPRInT), the NSF-PREM Center for Interfacial Electrochemistry of Energy Materials (CIE^2M), the NSF-CREST Center for Innovation, Research and Education in Environmental Nanotechnology ($CIRE^2N$), and the Research Training Initiative for Student Enhancement (RISE) Program.

L. Catalog and promotion

The program is promoted with the flyer of the Chemistry Graduate Program, the campus webpages and the Facebook pages of the Department of Chemistry and the College of Natural Science. The Catalog of courses for the M.S. in Chemistry Program is currently available to all interested students in the webpage of the Deanship of Graduate Studies and Research.

M. Budget Plan

Currently the Chemistry Graduate Program has no budget assigned to it in the annual budget of the Department of Chemistry or the College of Natural Sciences. All expenses to run the program are covered by the Department of Chemistry budget. A line item in the Department of Chemistry budget for travel is reserved for use by the Chemistry Graduate Program to cover the travel expenses of the speakers invited to participate in our Graduate Seminar Series. We would also like also for the line item in the Department of Chemistry budget for solvents, dry ice, gas tanks and liquid nitrogen be reserved for use by Chemistry Graduate Program.

The most recent self-study of the current M.S. and Ph.D. programs, which covered the academic years 2009-2010 to 2014-2015, described the lack of a separate budget for the Chemistry Graduate Program as a weakness of the program. Six years later, this is still the case. The program is embarked right now in a new self-study that will cover the period 2015-2016 to 2019-2020 and it will describe that this weakness remains.

Since all funds needed to run the program come out of the assigned budget to the Department of Chemistry, **this proposal for establishment of a M.S. program (no thesis) will have no budget impact**.

N. Assessment of the program and Student Learning Assessment Plan

1. Development Plan - The Chemistry Graduate Program has a five-year development plan submitted in 2016 that will be updated this year as part of the response to the self-study evaluation of the program currently underway. Every five years we administer a questionnaire to current students, alumni and professors of the program. The information obtained is used to assess the current program and propose any necessary changes. Part of the justification to embark in the preparation of this proposal was the results of the last questionnaire from 2015-2016.

   The next five-year development plan due in September 2021 will include ways to assess the implementation of the approved revisions of the M.S. and Ph.D. programs and the establishment of the new M.A. program.

2. **Student Learning Assessment Plan**

The Student Learning Assessment Plan of the Chemistry Graduate Program is based on the development of established learning domains for all students on campus, which includes the graduate students in our current programs (M.S., and Ph.D.). The development of those learning domains among the students in these programs will allow them, at the end of their graduate studies, to fulfill the new alumnus profile (Appendix 2). The assessment plan uses an evaluation model of the UPR Division of Institutional Research and Assessment (DIRA) of the Deanship of Academic Affairs. The assessment is based on certain learning domains with their learning objectives and the courses where they will be evaluated to access student learning in each of those domains. In the first semester of the 2019-2020 Academic Year the program submitted the required three-year and annual plans (see tables of the three-year plan and the Annual Assessment Plan submitted and approved by the DIRA). These tables will be used as part of the Assessment Plan for the new M.A. program. We will use the online OLAS system for these assessments. The annual reports will be shared with the entire Program's faculty and an action plan will be established to correct identified problem

areas. The student learning assessment information will be used to assess how the program is fulfilling its student learning goals as well as the graduate program development goals. Table 21 shows a summary of the three-year plan, which is presented in Table 22. Table 23 is the annual assessment plan.

VIII. Description of the proposed changes to the current Ph.D. in Chemistry Program:

A. General description of the proposed revised Ph.D. in Chemistry program

The revised Doctoral Chemistry Program will consist of a maximum of 59/47/53 credits depending on whether the student is admitted to the Ph.D. program with a B.S. in Chemistry (and then will require 59 credits to complete the Ph.D.), or with a M.S. in Chemistry or its equivalent (and then will require 47 credits to complete the Ph.D.) or with a M.S. in Chemistry or its equivalente but does no pass the entrance the entrance exam in his/her area of specialization (that student will have to take the two semesters of the core course in that area, adding 6 more credits to the total and therefore will require 53 credits to complete the Ph.D.) The revised Doctoral Chemistry Program requirements are tabulated at the end of this section.

1. **Title of the Program and Degree:** The revised Ph.D. in Chemistry Program will be part of the **Chemistry Graduate Program** and will lead to Ph.D. in Chemistry degree with a subspecialty in Analytical Chemistry, Biochemistry, Inorganic Chemistry, Organic Chemistry or Physical Chemistry.
2. **Description of the program (Summary of the Revised Ph.D. in Chemistry Program components):** The revised Ph.D. in Chemistry program will consist of a maximum of 59 credits and will be in compliance with Certification No. 95 of the Academic Senate, 2019-2020 Academic Year (Academic Policy for Graduate Studies of the Río Piedras campus). The revised Ph.D. in Chemistry requirements are tabulated at the end of this section.
3. **Program Modalities:** The Ph.D. in Chemistry will be obtained through a combination of “in person” teaching, training and learning, and other non-traditional teaching/learning strategies, including hybrid and online distance education.
4. **Starting Date of the Revised Ph.D. in Chemistry Program:** Academic Year 2021-2022.

5. **Duration of the revised Ph.D. in Chemistry program:** The expected duration of the program for full-time students will be five (5) years. The expected duration of the program for part-time students will be six (6) years. The maximum time to complete the program for full-time students will be seven (4) years and for part-time students will be 8 years.

B. Professional accreditation

Although our campus' B.S. in Chemistry program is accredited by a professional association, the American Chemical Society (ACS), this professional organization does not accredits graduate programs in Chemistry. Therefore, our Master's and Ph.D. program are not eligible for accreditation from a professional association. By law, chemists in Puerto Rico working outside of academia but possess at least a B.S. in Chemistry degree and be licensed to practice the profession by the Chemists Examining Board of the Department of State of Puerto Rico.

C. Relation of the academic program with the current mission and Strategic Plan of the UPR and the Río Piedras Campus

The proposed revised Ph.D. in Chemistry Program is aligned with the current Mission and Strategic Plan 2017-2022 of the University of Puerto Rico (Certificate No. 50, 2016-2017, of the Governing Board) and with the Strategic Plan 2018-2023 of the Río Piedras Campus (Certificate No. 79, 2017-2018, of the Academic Senate). The program emphasizes (a) to achieve and maintain excellence in education, research and dissemination of knowledge, (b) a commitment to the integral formation of the student and his lifelong learning; (c) the dissemination of knowledge at the national and international level and (d)to contribute to the scientific, social and economic development of the country to improve the quality of life in Puerto Rico, the Caribbean and the world.

The Program is consistent with the Mission of the Río Piedras Campus in terms of providing graduate education of the highest quality that develops capacities for independent study and research and helps strengthen undergraduate education. In addition, in the training of professionals of the highest caliber, committed to the ideals and values of Puerto Rican society. Likewise, to develop teaching, research and development, and the dissemination of knowledge at an international level.

D. Conceptual Framework

1. **Vision:** We aim to develop lifelong learning, creation and dissemination of knowledge at national and international level and the training of professionals of chemistry that promote scientific, social, and economic development, to improve the quality of life in Puerto Rico, the Caribbean, and the world.
2. **Mission:** The mission of the Ph.D. program of the Chemistry Graduate Program is to educate and train professionals with knowledge in the fundamentals of chemistry, while providing an enabling experience in a specific area belonging to one of the classic branches (Analytical Chemistry, Biochemistry, Inorganic Chemistry, Organic Chemistry, Physical Chemistry) or emerging interdisciplinary branches such as materials science, bioinorganic chemistry, supramolecular chemistry and nanotechnology, among others. The preparation of professionals in chemistry at an advanced level also seeks to develop in them the importance of creating a safe environment in the work area, the ability to identify major problems in the discipline and to design effective strategies for solving them by encouraging good laboratory practices, interdisciplinarity and collaboration at the departmental, national, and international level. In a broader context, the mission of the Graduate Program is to prepare professionals to practice their profession with the firm intention of advancing knowledge in chemistry, bringing this knowledge to solve problems of daily life and human welfare while instilling in our students hard and soft skills sets that will directly prepare them for post-graduate work and to promote scientific, social, and economic development to improve the quality of life in Puerto Rico, the Caribbean, and the world.
3. **Goals:** The Chemistry Graduate Program is the product of an urgent need to create the intellectual resources needed to make Puerto Rico an attractive place for the development of new technologies and enterprises with capable personnel, who have the capacity of adapting to the changing paradigm of science and technology entrepreneurship while promoting scientific, social, and economic development in Puerto Rico, the Caribbean, and the world. The objectives of the program are:
    a. To provide the basic theoretical-practical knowledge required to perform as a competent professional in the area of chemistry

b. To encourage scientific, creative and critical research, framed in the ethical - professional commitment.
c. To contribute to the solution of issues and problems related to Chemistry and the sciences, arts and industries related to it.
d. To advance the knowledge of Chemistry and ensure human well-being by providing ideas for solving problems in society beyond the research laboratory.
e. To link the University with the world reality to improve the well-being of the human being.
f. To contribute to the improvement of undergraduate programs through research opportunities, exchange of ideas and activities with graduate studies.
g. To offer chemical advice to the community, the country's educational system, the government, and industries.
h. To identify institutional and external funds to provide a physical and administrative infrastructure that allows sustaining and optimizing the operation of the program to efficiently serve a heterogeneous audience of students and professionals.

4. **Philosophy:** Both the Chemistry Department at UPR-RP and its Chemistry Graduate Program are dedicated to serve Puerto Rico by developing professionals capable of contributing to the scientific, technological, and socio-economic growth of Puerto Rico and the world.
5. **Proposed revised Ph.D. in Chemistry Program alumnus profile (in compliance with the Graduate Student Alumnus Profile of the Río Piedras Campus - Certification No. 104, Academic Senate, 2016-2017 Academic Year, see Appendix 2):** At the end of their graduate studies, students are expected:
    1. To conduct creative, critical and innovative scientific research to offer solutions and generate knowledge framed in an ethical-professional commitment as learned through problem solving based learning strategies in the program.
    2. To know and critically evaluate the scientific literature and methodology and use the obtained information in problem solving.
    3. To exercise independence of opinion and show creativity and initiative to contribute to the solution of matters and problems related to Chemistry and the

sciences, arts, and enterprises related to it.

4. To integrate theories and practical protocols that protect the environment and ethical and security codes in his/her professional and research endeavors.
5. To know the scientific literature and manage information in a critical, effective and ethical way for problem solving.
6. To incorporate current instrumentation and technological resources as resource tools in the design of experiments and in problem solving.
7. To communicate effectively the fundamentals of his/her discipline to the scientific community and to diverse groups in a clear and logical manner.
8. To show commitment with the protection of natural, environmental, and cultural resources through Chemistry best practices and the occupational safety and environmental protection norms.
9. To show respect to human rights through actions of social inclusiveness and commitment to diversity.
10. To demonstrate collaborative research actions through multi-, inter-, and transdisciplinary teamwork.
11. To assume and encourage leadership that contributes to individual and collective transformations.
12. To master the concepts and fundamentals of Chemistry, of its diverse applications in daily life and its relationship with other scientific disciplines.
13. To master the technical skills required for the exercise of his/her profession as a chemist.
14. To show mastery of knowledge in instrumentation and technical skills within their specialty in Chemistry.
15. To identify important problems inherent to Chemistry and other disciplines to design effective strategies and/or experiments for their solution.
16. To demonstrate capacity to undertake original research beyond their thesis and to direct an independent research group in academia, industry or government.
17. To show capacity to apply chemical knowledge, skills, and ethical conduct in the solution of real problems associated with the Chemistry field that promote scientific, social, and economic development to improve the quality of life in

Puerto Rico, the Caribbean and the world.

2. **Coherence and sufficiency:** The components of the conceptual framework are coherent and sufficient and meet the conditions to provide the necessary structure to the proposed program. The harmony and logical and consequent relationship between the Mission, Goals, Objectives, and the Alumnus Profile allows the program to successfully continue to pursue its Vision.

E. Curricular design (proposed revised graduation requirements)

1. **General requirements:** The revised Ph.D. in Chemistry Program candidates must comply with the general graduation requirements that are mandated by the UPR-RP Campus.
2. **Curriculum requirements (see Table 16):**
   a. **Course work: –** Complete a minimum of **twenty-one (21) credits** in graduate courses (Students in the Ph.D. program that already have a M.S. degree and pass the placement exams will not be required to take the three core courses). During their first year, the graduate student must consult with the Graduate Program Coordinator about which courses to take prior to enrollment. Beyond their first year, graduate students must consult their thesis adviser about which courses to take prior to enrollment. The thesis adviser might recommend the student to take courses in another discipline, for example, Biology, Physics, or Mathematics when these courses are deemed necessary for the student's development as an independent researcher.
      1. Twelve (12) credits of 6000-8000 level graduate chemistry courses.
      2. Nine (9) credits in graduate level electives; six (6) of which should be at an 8000 level and including one three (3) credit Scientific Writing Course elective described below.
         (See list of courses in Appendix 1).

   b. **Rotations.** The students can voluntarily enroll in the graduate rotation course. In this course the student most attend the rotating laboratory group meetings and pertinent research activities to gain a better understanding of the group's dynamics and research interests. The student enrolled in the graduate rotation course needs to perform three (3) three-week rotations during their first

semester in the Program. At the end of the first semester the student will choose a laboratory and therefore a thesis adviser for his/her Ph.D. project. This is a zero credit course.

c. **Candidacy exam.** At the end of the first year in the Doctoral Graduate Program, the student will take a candidacy exam in the first (1^{st}) semester of their second (2^{nd}) year that will consist of applied questions that pertain to the students' field of research interest. A candidacy committee will prepare the oral and written components of this exam. The students will write formal responses to the questions and defend their answers in a meeting with the committee. *Students will be given no more than two (2) opportunities to pass the candidacy exam.* A student in good standing that fails this requirement will be allowed to pursue either a M.S. or a M.A. degree.

d. **Scientific writing course:** Enroll in a three (3)-credit Scientific Writing Course. The course will serve to introduce scientific writing tools and methods for publications, fellowships, and grant proposals writing. The final product of the course should be the development of a written original research proposal that enhances the student's understanding of science and scientific writing (similar to a National Science Foundation-Graduate Research Fellowship Program Application, Federal Grant Proposal/National Institutes of Health supplement, or Private Agency External Funds Application). This proposal should be of sufficient quality as one to be submitted to try to obtain external funding for this student. Students taking this course should have already passed their candidacy exam or take the course in the same semester that they will take their candidacy exam. The students will take this Scientific Writing Course during the first (1^{st}) semester of their second (2^{nd}) year in the Chemistry Graduate Program.

e. **Research plan proposal:** The student most present a (10-page maximum) research proposal plan and submit this document to *all* Thesis Committee Members two (2) weeks prior to the proposal defense date. The research proposal must be successfully defended in front of the student's Thesis Committee Members; each of whom will complete a rubric about the student

performance on this requirement for assessment purposes. No preliminary data is required for this proposal, although feasibility of the project should be established with previous work from the laboratory or literature. The Thesis Research Proposal requirement also encompasses an oral exam in the student's area of specialty within the context of the proposed research activities. If the student fails the research plan proposal defense, he/she will have to repeat it during the summer months. In the event that a student fails the research plan proposal examination on the second attempt, the student will be dropped from the Chemistry Graduate Program. The research plan proposal should be completed by the end of the second (2^{nd}) semester of their (2^{nd}) second year in the Chemistry Graduate Program unless another attempt is required, which should take place during the summer months. The Thesis Committee Members should make evaluation for the merit of further attempts. The Thesis Committee and the student will determine if the presentation and defense will be public or private.

f. **Original Research Proposal.** The student must defend their original research proposal, first developed in the Scientific Writing Course, no later than the second (2^{nd}) semester of their third (3^{rd}) year in the program. The original research proposal should be first presented orally in front of the whole Chemistry Graduate Program as part of the Chemistry Seminar Series in the form of a 45 min long seminar, followed by a closed oral defense with all the Thesis Committee members. The Thesis Adviser will be allowed to actively participate in the defense portion. The students will be given two (2) opportunities to successfully complete the original research proposal requirement, as a whole or in its parts. An abstract of the original research proposal should be submitted one month in advance to all the Thesis Committee members (not only the adviser) sometime during the first (1^{st}) semester of their third (3^{rd}) year in the Chemistry Graduate Program.

g. **Graduate seminar:** The student must enroll and attend the graduate seminar course (QUIM 8901-8902) every academic year until they present their own Original Research Proposal as part of the Graduate Seminar Series. *Students*

are strongly encouraged to continue participating in the graduate seminars because they contribute to their scientific growth and understanding. In year three, students will present a research seminar where they will offer a perspective on the field of their research and the contributions that their research is making to the field. An accompanying manuscript will be prepared prior to the seminar presentation. This seminar will be a combination of a perspective report and research and will include a written component. The thesis committee will evaluate the work. The written document could be transformed to a review to be submitted and count as a publication. Only **two (2) credits** of the graduate seminar course (QUIM 8901-8902) will count towards the graduate degree.

h. **Focused research seminar:** The student must enroll and attend the focused research seminars of their research group every semester (commonly referred as "group meetings". The student needs to approve a minimum of twelve (12) credits in CHEM 800X (X depending on area of specialty). Candidates coming to the Graduate Chemistry Program with a Master's degree or equivalent will need to approve a minimum of ten (10) credits in CHEM 800X (the X in the course number will depend on area of specialty).

i. **Graduate research:** Enroll in a minimum of eighteen **(18) credits** of graduate research (CHEM 8999). Based on their graduate research the student must write and successfully defend a Doctoral Thesis.

j. **Teaching Assistantship:** Enroll in at least one academic year **(6 credits)** of CHEM 6905-6906 Principles and Practices of Chemistry. If a student participates of an academic, industrial or government sponsored internship during the course of their PhD, the student can write a petition to the Academic Affairs Committee to substitute up to 3 credits for this requirement.

k. **Publications:** Students will be required to publish three (3) high-quality peer-reviewed papers, one of which should be a first-author paper as a result of their thesis. One of these papers could be a review or contributing chapter from the Scientific Writing Course or other courses.

l. **Thesis Writing:** The student needs to enroll in the course CHEM 6896: Thesis Continuation. Based on their graduate research, the student must write a thesis representative of his/her contribution to science. Students that have not completed the defense of their Original Research Proposal will not be allowed to enroll in the Thesis-writing Course, except by consensus of the Academic Affairs committee. A limit of one (1) year will be established for the Thesis Writing Stage. This is a zero credit course.

3. **Additional requirements:**

a. **Placement exams:** Upon acceptance into the Chemistry Graduate Program, students will be required to take an entrance placement exam to demonstrate basic knowledge in each of these areas: Analytical, Biochemistry, Inorganic, Organic, and Physical Chemistry**.** The results of the placement exam will be shared with all professors of the Chemistry Graduate Program so that each division can assess how to help the student reach the academic standards that are expected for every graduate in the Chemistry Graduate Program. In addition, the results will be used to help develop the first annual Individualized Development Plan (IDP) for the student in conjunction with the division(s) and/or the Program Coordinator. The final IDP should be submitted and approved by the Graduate Affairs Committee. An annual IDP will be required for all graduate students in a format similar to the ChemIDP of the American Chemical Society (https:chemidp.acs.org) or the MyIDP of the American Association for the Advancement of Science (http://myidp.sciencecareers.org) throughout every year of the program.

b. **Rotations.** The students can voluntarily participate in the graduate rotation program during the first (1^{st}) semester of their first (1^{st}) year in the Chemistry Graduate Program. In this program the student must attend the rotating laboratory group meetings and pertinent research activities to gain a better understanding of the group's dynamics and research interests. The student needs to perform three (3) three-week different rotations during a one-semester period. *At the end of the first semester the student will choose a*

laboratory and therefore a thesis adviser for his/her doctoral research project.

c. **GPA requirements and candidacy exam:** Students must earn at least a **C** in each course and an overall GPA of 3.0 at the completion of the first year of courses to be in good standing. Students who earn more than a 2.5 but below 3.0 GPA will be on probation for up to one year, but will be allowed to take the candidacy exam and must repeat the course with the deficiency to raise their GPA to 3.0 upon completion of the second year. Students who earn less than a 2.5 will be placed on probation for one year or one semester if he/she entered the Program conditionally. If a student earns a GPA above 3.5 (with two A's in the courses in their area of specialty), the student will be exempt from the mandatory candidacy exam. The minimum GPA for graduation will be of 3.0 in a scale of 4.0. A student that falls below a 3.0 GPA will be in a probation period of one (1) year if the student entered as a regular student, and a probation period of one (1) semester if the student entered the Program conditionally. During the probation period research or teaching assistantships might not be available. Students that are not in good standing after the allotted academic probation period will be dropped from the Graduate Program. A student in good standing that fails the candidacy exam requirements will be allowed to pursue a M.S. degree. A student in good standing that completes 30 credits towards the Ph.D. degree will be eligible for a M.A. degree and to continue towards their Ph.D.

d. **Candidacy:** The student should be recommended to be a candidate for a Doctor's in Philosophy based on his/her academic achievements and performance in the candidacy exam. A recommendation letter by the Academic Affairs Committee and the Program Coordinator of the Chemistry Department will be sent to the Register. This promotion should take place within a maximum of two (2) years from the date of admission to the Chemistry Graduate Program.

e. **Public speaking workshop:** A public speaking workshop will be offered to all graduate students once a year.

f. **Thesis committee.** A thesis committee must be composed a *minimum of three (3)* members with a Ph.D. or equivalent degree, one of which has to be the candidate's thesis adviser. *The thesis adviser must be an active member of the Chemistry Graduate Program at UPR-RP.* At least one (1) other committee member has to be a person with either academic or industrial expertise in the area of the candidate's dissertation research. The selection of the committee members needs to be approved by the thesis adviser in *a prior* agreement with the student. At the time of the Thesis Research proposal, one committee member will be assigned as the Chair of the Thesis Committee (this person cannot be the Ph.D. candidate adviser). The Ph.D. candidate will meet yearly with the Chair of the Thesis Committee for evaluation of the student's progress towards completing the Ph.D. If any disputes between the student and the adviser or any member of the thesis committee arise, the Chair of the Thesis Committee will inform the Chemistry Program Coordinator to act accordingly. All members of the committee need to *participate (be present)* for the thesis defense to proceed.

g. Ph.D. seminar: Based on their graduate research the students must successfully present and defend their dissertation to the Graduate Program. The dissertation presentation and defense will be public. *A limit of one year will be established for the thesis writing stage.*

Table 16 shows a summary of the revised Ph.D. in Chemistry program requirements.

Table 16. Summary of the revised Ph.D. in Chemistry Program requirements.

Revised Ph.D. in Chemistry Program Requirements	**Credits (Coming into the Ph.D. with a B.S./with a Master's/with a Master's but do not pass the Entrance Exam in their area)**
Graduate Chemistry Core Courses (6000 level)	12/0/6
Free Elective Courses (8000 level)	6
Scientific Writing Course (8000)	3
Teaching Assistantship/Internship (Principles and Practices) (6905)	6
Laboratory Rotations (8000)	0
Candidacy Exam	0
Thesis Research Proposal	0

Original Research Proposal	0
Graduate Seminars (8901/8902)	2
Focused Research Seminar (8XXX)	12
Graduate Research (8999)	18
Thesis Writing (Dissertation Continuation) (8896)	0
Total credits	***59/47/53***

4. **Proposed course sequence**

Table 17 shows the proposed course sequence for full-time students in the revised Ph.D. program.

Table 17. Proposed course sequence for **full-time students** enrolled in the revised Ph.D. in Chemistry program (59 credits)*

First Year					
First Semester			**Second Semester**		
Course Code	**Description**	**Credits**	**Course Code**	**Description**	**Credits**
CHEM 6905	Teaching Assistantship	3	CHEM 6906	Teaching Assistantship	3
CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3	CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3
CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3	CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3
CHEM 8999	Laboratory Rotations	0	CHEM 8902	Graduate Seminar	1
CHEM 8901	Graduate Seminar	1			
	Total	10		*Total*	10
First Summer					
Milestone 1: Candidacy Exams (pass required qualifying exams)					
Second Year					
Third Semester			**Fourth Semester**		
Course Code	**Course Name**	**Credits**	**Course Code**	**Course Name**	**Credits**
CHEM 6905	Teaching Assistantship	3**	CHEM 6906	Teaching Assistantship	3*
CHEM 6000	Chemistry Elective Course***	3	CHEM 8000	Scientific Writing	3
CHEM 6000	Chemistry Elective Course***	3	CHEM 8000	Focused Research Seminar	3
CHEM 8000	Focused Research Seminar	3	CHEM 8999	Graduate Research	3
CHEM 8999	Graduate Research	3	**Milestone 2:** Thesis Research Proposal		
	Total	12/15*		*Total*	9/12*
Third Year					
CHEM 6905	Teaching Assistantship	3*	CHEM 6906	Teaching Assistantship	3*
CHEM 8000	Focused Research Seminar	3	CHEM 8000	Focused Research Seminar	3
CHEM 8999	Graduate Research	6	CHEM 8999	Graduate Research	6
			Milestone 3: Peer-reviewed publication		
	Total	9/12**		*Total*	9/12**
Fourth Year and Beyond					
Seventh Semester			**Eight Semester**		
Course Code	**Course Name**	**Credits**	**Course Code**	**Course Name**	**Credits**
CHEM 6905	Teaching Assistantship	3*	CHEM 6906	Teaching Assistantship	3*
CHEM 8896	Dissertation Continuation	0	CHEM 8896	Dissertation Continuation	0
	Total	0/3**		*Total*	0/3**
CHEM 8895/8896: Dissertation Continuation (beyond the fifth year) – 0 credits **Milestone 4:** Thesis Presentation and Defense					

*See list of graduate courses in Appendix 1. There are five Chemistry Graduate Core Courses (two semester courses, therefore actually ten courses) at the 6000 level, one for each one of the core areas of Chemistry: Analytical (CHEM 6215/6225), Biochemistry (CHEM 6811/6812), Inorganic (CHEM 6011/6012), Organic (CHEM 6411/6412) and Physical Chemistry (CHEM 6611/6612). The CHEM 8999 course is the Research for the Doctoral Dissertation course, but it is being currently used as a one credit course for the

rotation requirement for incoming new graduate students in the program. There are five Seminar in Chemistry courses at the 8000 level (two semester courses, therefore actually ten courses), one for each one of the core areas of Chemistry: Seminar in Analytical Chemistry (CHEM 8205/8206), Seminar in Biochemistry (CHEM 8801/8802), Seminar in Inorganic Chemistry (CHEM 8005/8006), Seminar in Organic Chemistry (CHEM 8405/8406) and Seminar in Physical Chemistry (CHEM 8605/8606). We propose to change the name of the Seminar in Chemistry courses to Focused Research Seminar in Chemistry, maintaining their current course codes.
** For students that due to financial reasons, need to continue being teaching assistants. The Ph.D. program has a one-year Teaching Assistant requirement.
***A student might take elective courses in areas other than Chemistry if in consultation with the advisor it is decided that taking that course(s) will help the student complete the thesis project.

The Chemistry Graduate Program offers courses in five areas of Chemistry: Analytical Chemistry, Biochemistry, Physical Chemistry, Inorganic Chemistry, and Organic Chemistry. During the first year in the program, students can take two core courses in two of these five areas. In later years, students can take elective/advanced courses in their area of specialty, as well as elective courses from any other area (even from areas outside the Program, say courses from the Graduate Program in Biology, or Physics or Environmental Sciences, depending if the student and his/her mentor determine it is necessary to assist the student in their master's thesis or doctoral dissertation work). Core courses from the other areas that the student did not take courses in their first year in the program may be taken by these students as elective courses. All those courses currently have a code. For this reason, currently there is no elective course that is in the process of obtaining a code. Furthermore, there are advanced 8000 level courses called Special Topics Course for each of the five areas. In each area, with the same code, different courses of this type can be offered, just by changing the course title (for example, QUIM 8990-Special Topics in Inorganic Chemistry - Bioinorganic Chemistry and QUIM 8990-Special Topics in Inorganic Chemistry - Crystallography). These are state-of-the-art courses are offered on the latest and greatest issues in the area of Chemistry. Some of these courses have been offered for several years and there is interest in their conversion to separate courses with separate codes. But for this proposal for the revision of the M.S. and Ph.D. Chemistry programs and the establishment of the new M.A. in Chemistry program, we do not need to already have a code for those course since they are already being currently offered within a course with a code and can be taken as electives right now.

Table 18 shows the proposed course sequence for graduate students who enrolled in our Ph.D. in Chemistry program with already a M.S. in Chemistry degree or in a related field from an accredited institution.

Table 18. Proposed Course Sequence for **full-time students** enrolled in the Ph.D. in Chemistry program with already a M.S. in Chemistry degree or in a related field from UPR or other accredited Institutions. (**47 credits total**)* If the student does not pass the Placement Exam in their area of specialty, then she/he will have to take two Chemistry Graduate Courses at the 6000-8000 level in that same area. (**53 credits total**)

First Year					
First Semester			**Second Semester**		
Course Code	**Description**	**Credits**	**Course Code**	**Description**	**Credits**
CHEM 6905	Teaching Assistantship	3	CHEM 6906	Teaching Assistantship	3
CHEM 6000-8000	Chemistry Graduate Course	3**	CHEM 6000-8000	Chemistry Elective Course***	3**
CHEM 6000-8000	Chemistry Elective Course***	3	CHEM 8999	Graduate Research	6
CHEM 6000-8000	Chemistry Elective Course***	3	CHEM 8902	Graduate Seminar	1
CHEM 8999	Laboratory Rotations	0			
CHEM 8901	Graduate Seminar	1			
	Total	*10/13***		*Total*	*10/13***

First Summer					
Milestone 1: Candidacy Exams Period (pass required qualifying exams)					
Seconds Year					
Third Semester			**Fourth Semester**		
Course Code	**Course Name**	**Credits**	**Course Code**	**Course Name**	**Credits**
CHEM 6905	Teaching Assistantship	3**	CHEM 6906	Teaching Assistantship	3**
CHEM 8000	Focused Research Seminar	3	CHEM 8000	Focused Research Seminar	3
CHEM 8999	Graduate Research	3	CHEM 8999	Graduate Research	3
CHEM 8000	Scientific Writing Course	3	**Milestone 2:** Thesis Research Proposal		
	Total	*9/12***		*Total*	*6/9***
Third Year					
Fifth Semester			**Six Semester**		
CHEM 6905	Teaching Assistantship	3**	CHEM 6906	Teaching Assistantship	3**
CHEM 8000	Focused Research Seminar	3	CHEM 8000	Focused Research Seminar	3
CHEM 8999	Graduate Research	3	CHEM 8999	Graduate Research	3
			Milestone 3: Peer-reviewed publication and Presentation		
	Total	6/9**		*Total*	6/9**
Fourth Year and Beyond **CHEM 8895/8896: Dissertation Continuation (beyond the fifth year) – 0 credits** **Milestone 4:** Thesis Presentation and Defense					

*See list of graduate courses in Appendix 1. There are five Chemistry Graduate Core Courses (two semester courses, therefore actually ten courses) at the 6000 level, one for each one of the core areas of Chemistry: Analytical (CHEM 6215/6225), Biochemistry (CHEM 6811/6812), Inorganic (CHEM 6011/6012), Organic (CHEM 6411/6412) and Physical Chemistry (CHEM 6611/6612). The CHEM 8999 course is the Research for the Doctoral Dissertation course, but it is being currently used as a one credit course for the rotation requirement for incoming new graduate students in the program. There are five Seminar in Chemistry courses at the 8000 level (two semester courses, therefore actually ten courses), one for each one of the core areas of Chemistry: Seminar in Analytical Chemistry (CHEM 8205/8206), Seminar in Biochemistry (CHEM 8801/8802), Seminar in Inorganic Chemistry (CHEM 8005/8006), Seminar in Organic Chemistry (CHEM 8405/8406) and Seminar in Physical Chemistry (CHEM 8605/8606). We propose to change the name of the Seminar in Chemistry courses to Focused Research Seminar in Chemistry, maintaining their current course codes.
** For students that due to financial reasons, need to continue being teaching assistants. The Ph.D. program has a one-year Teaching Assistant requirement.
***A student might take elective courses in areas other than Chemistry if in consultation with the advisor it is decided that taking that course(s) will help the student complete the thesis project.

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Table 19 shows a comparison between the current curriculum and the proposed revised one.

Table 19: Table Comparing Current and Proposed Curriculum in the Ph.D. in Chemistry Program.*

Current Curriculum			**Proposed Curriculum (Reduction of credits and Inclusion/exclusion of non-credit requirements)**		
PhD in Chemistry with specialty in Analytical Chemistry, Organic Chemistry, Inorganic Chemistry, Physical Chemistry, or Biochemistry.			PhD in Chemistry with specialty in Analytical Chemistry, Organic Chemistry, Inorganic Chemistry, Physical Chemistry, or Biochemistry. **Requirements for PhD candidates entering the program with a Master's degree or equivalent. (**47 credits total**) *** Requirements for PhD candidates entering the program with a Master's degree or equivalent if they do not pass Entrance Exam in the area of their specialty. (**53 credits total**)		
Core Courses			**Core Courses**		
Course Code	**Course Name**	**Credits**	**Course Code**	**Course Name**	**Credits**
CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3	CHEM 6000-8000	Graduate Core Course	3

CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3	CHEM 6000-8000	Graduate Core Course	3
CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3	CHEM 6000-8000	Graduate Core Course	3
CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3	CHEM 6000-8000	Graduate Core Course	3
CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3			
CHEM 6000	Chemistry Graduate Core Course at the 6000 level	3			
	Total	*18*		*Total*	*12/0***
Elective Courses			**Elective Courses**		
Course Code	**Course Name**	**Credits**	**Course Code**	**Course Name**	**Credits**
CHEM 6000-8000	Elective Course****	3	CHEM 6000-8000	Elective Course****	3
CHEM 6000-8000	Elective Course****	3	CHEM 6000-8000	Elective Course****	3
CHEM 6000-8000	Elective Course****	3			
CHEM 6000-8000	Elective Course****	3			
	Total	*12*		*Total*	*6*
Other Chemistry Courses			**Other Chemistry Courses**		
Course Code	**Course Name**	**Credits**	**Course Code**	**Course Name**	**Credits**
CHEM 8999	Graduate Rotations	1	CHEM 8999	Graduate Rotations	0
CHEM 8901	Graduate Seminar	1	CHEM 8901	Graduate Seminar	1
CHEM 8902	Graduate Seminar	1	CHEM 8902	Graduate Seminar	1
CHEM 8999	Graduate Research	24	CHEM 8999	Graduate Research	18
CHEM 8000	Seminar in Chemistry	12	CHEM 8000	Focused Research Seminar	12
CHEM 6905	Principles and Practices	6	CHEM 6905	Principles and Practices	6
			CHEM 8000	Scientific Writing Course	3
			CHEM 8000	Chemistry Elective Course	3***
			CHEM 8000	Chemistry Elective Course	3***
	Total	*45*		*Total*	*41/47****
Thesis Courses			**Thesis Courses**		
Course Code	**Course Name**	**Credits**	**Course Code**	**Course Name**	**Credits**
CHEM 8895/8896	Dissertation Continuation	0	CHEM 8895/8896	Dissertation Continuation	0
	Total	*0*		*Total*	*0*
	Total Number of Credits	***75***		***Total Number of Credits***	***59/47**/53****

*See list of graduate courses in Appendix 1. There are five Chemistry Graduate Core Courses (two semester courses, therefore actually ten courses) at the 6000 level, one for each one of the core areas of Chemistry: Analytical (CHEM 6215/6225), Biochemistry (CHEM 6811/6812), Inorganic (CHEM 6011/6012), Organic (CHEM 6411/6412) and Physical Chemistry (CHEM 6611/6612). The CHEM 8999 course is the Research for the Doctoral Dissertation course, but it is being currently used as a one credit course for the rotation requirement for incoming new graduate students in the program.

There are five Seminar in Chemistry courses at the 8000 level (two semester courses, therefore actually ten courses), one for each one of the core areas of Chemistry: Seminar in Analytical Chemistry (CHEM 8205/8206), Seminar in Biochemistry (CHEM 8801/8802), Seminar in Inorganic Chemistry (CHEM 8005/8006), Seminar in Organic Chemistry (CHEM 8405/8406) and Seminar in Physical Chemistry (CHEM 8605/8606). We propose to change the name of the Seminar in Chemistry courses to Focused Research Seminar in Chemistry, maintaining their current course codes.

** For students that enter the program with a M.S. degree.

*** For students that enter the program with a M.S. degree, but do not pass the placement entrance exam in their area of specialization.

****A student might take elective courses in areas other than Chemistry if in consultation with the advisor it is decided that taking that course(s) will help the student complete the thesis project.

Table 20 shows other changes to requirements of the Ph. D. in Chemistry program.

Table 20. Other Changes to Requirements for the Curriculum in the Ph.D. in Chemistry Program.

Current Non-credit Requirements		**Proposed Non-credit Requirements**	
Name	**Description**	**Name**	**Description**
Placement Exams	Students will be required to take four (4) entrance exams corresponding to the following department subdivisions; Inorganic, Organic, Physical, and Analytical.	Placement Exams	Upon acceptance into the Doctoral Graduate Program, students will be required to take an entrance placement exam to demonstrate basic knowledge in each of these areas; Analytical, Biochemistry, Inorganic, Organic, and Physical Chemistry.
Graduate Rotations	The students must participate in the graduate rotation program during the first semester of their first year in the Program to explore research interest and dynamics of three different groups within the Chemistry Graduate Program. *Required.*	Graduate Rotations	The students must enroll in the graduate rotation course to explore research interest and dynamics of three different groups within the Chemistry Graduate Program. *This is a zero credit course requirement conducive to the degree.*
Qualifying Exams	Students are required to pass two (2) qualifying exams. The student must pass one (1) qualifying exam in their area of specialty. *Required.*	Candidacy Exam	Students will take a candidacy exam in the 1st semester of their second year that will consist of applied questions that pertain to the students' field of research interest. These questions will be prepared by a candidacy committee. The students will write formal responses to the questions and defend their answers in a meeting with the committee. *Required.*
Proposal A	A research plan must be successfully depended in front of the student's Thesis	Research Plan Proposal	The student must present a (10-page maximum) research proposal plan, and submit this document to

	Committee. This requirement also encompasses an oral exam in the student's area of specialty. *Required.*		all Thesis Committee Members two (2) weeks prior to the proposal defense date. The research proposal must be successfully defended in front of the student's Thesis Committee Members. No preliminary data is required for this proposal, although feasibility of the project should be established with previous work from the laboratory or literature. The Thesis Research Proposal requirement also encompasses an oral exam in the student's area of specialty within the context of the proposed research activities. If the student fails the research plan proposal defense, he/she will have one (1) semester to repeat it. In the event that a student fails the research plan proposal examination on the second attempt, the student will be dropped from the Chemistry Graduate Program. The research plan proposal should be completed by the end of the second (2nd) semester of their (2^{nd}) second year in the Chemistry Graduate Program unless another attempt is required, which should take place during the summer months. The Thesis Committee Members should make evaluation for the merit of further attempts. The student and the thesis committee will decide if the presentation and defense will be public or not. *Required.*
Proposal B	The presentation and oral defense of an original research proposal in front of the student's Thesis Committee. This requirement also encompasses an oral exam in the student's area of specialty.	Scientific Writing course (a written proposal component will be included in this course, but not the defense)	A three (3)-credit Scientific Writing Course. The course will serve to introduce scientific writing tools and methods for publications, fellowships, and grant proposals writing. The final product of the course should be the

			development of a written original research proposal (not strongly related to their research) that enhances the student's understanding of science and scientific writing (similar to a NSF-GRFP application, Federal Grant Proposal/NIH supplement, or Private Agency External Funds Application). This proposal should be of sufficient quality as one to be submitted to try to obtain external funding for this student. Students taking this course should have already passed the candidacy exam or take the course in the same semester that they will take the candidacy exam. The students will take this Scientific Writing Course during the first (1st) semester of their second (2nd) year in the Chemistry Graduate Program.
Graduate Seminar		Original Research Proposal Defense	The student must defend their original research proposal, first developed in the Scientific Writing Course, no later than the second (2nd) semester of their third (3rd) year in the program. The original research proposal should be first presented orally in front of the whole Chemistry Graduate Program as part of the Chemistry Seminar Series in the form of a 45 min long seminar, followed by a closed oral defense with all the Thesis Committee members. The Thesis Adviser will be allowed to actively participate in the defense portion. The students will be given two (2) opportunities to successfully complete the original research proposal requirement, as a whole or in its parts. An abstract of the original research proposal should be submitted one month in

			advance to all the Thesis Committee members (not only the adviser) sometime during the first (1st) semester of their third (3rd) year in the Chemistry Graduate Program.
Oral Thesis Defense	Oral presentation of the Ph.D. Dissertation. *Required.*	Ph.D. Dissertation Seminar:	Public oral presentation and defense of the Ph.D. Dissertation in front of the Thesis Committee Members. *Required.*
CHEM 6905: Principles and Practices	Enroll in at least one academic year of CHEM 6905-6906 Principles and Practices of Chemistry. *Required.*	CHEM 6905: Principles and Practices	The student must enroll at least one year in the course CHEM 6905-6906: Principles and Practices of Chemistry.

5. **Syllabi of course -** The syllabi of the courses for the revised Ph.D. in Chemistry Program remain the same as those of the current Ph.D. in. Chemistry program.

F. Admission, enrollment and graduation

1. Admission requirements: The applicant must have a bachelor's degree or its equivalent with an overall undergraduate grade point average of no less than 3.0 and no less that 2.75 in Chemistry, or a Master's degree. The applicant must have completed a one-year course in general chemistry, organic chemistry and physical chemistry, including laboratory work, and have at least one semester of analytical chemistry (including laboratory) and inorganic chemistry. The applicant must also have knowledge of mathematics through integral calculus, and one year of general physics. The applicant must have writing, reading, and conversational abilities in English given that courses are offered in this language (except in a course where all students are Spanish speakers, where the course in often given in Spanish). All students that enter the Ph.D. program will enter as Ph.D. candidates, contingent to the successful completion of the program requirements.

2. **Application Process:** To be considered for admission in August of the academic year, the applicant must fulfill and submit the application form located at the website: https://app.applyyourself.com/?id=upr-grad no later than December for international students and January for resident students. The applicant will be notified by e-mail from the Office of the Dean of Graduate Studies and Research regarding acceptance

to the Program, no later than March for the international students and April for resident students.

a. The applicant must submit two (2) official transcripts, which needs to include a degree certification at the following address: Graduate Programs and Research, University of Puerto Rico, Río Piedras Campus, 17 AVE Universidad STE 1701, San Juan PR 00925-2537, Physical address: Graduate Programs and Research, University of Puerto Rico, Río Piedras Campus, Natural Sciences Building, Phase II Room C-164, San Juan, Puerto Rico.

b. In the application form the student must include two (2) e-mail addresses of professors that will recommend him/her, from the university where the applicant earned the bachelor's or master's degree.

c. The applicant must include a Statement of Purpose document indicating his/her interests in pursuing graduate studies.

d. The applicant might be requested to attend a Personal interview (online or in person) with the Admissions Committee.

3. **Conditional Admission:** An applicant who fails to fulfill one or more of the admission requirements, but who otherwise shows promise as a graduate student, may be granted conditional admission to the Graduate Program. To be considered for conditional admission it is required that the student has a general minimum grade point average of 2.75 and a 2.50 in chemistry. In this case, the applicant will be informed of the conditions that he or she must satisfy to be considered a regular bonafide student. Conditional admission means that the student will be on probation for a period of one year until he or she demonstrates academic progress. The Admission Committee will advise the student on the development of a class program that complies with these requirements. The Graduate Affairs Committee will determine if the student has fulfilled all conditions established by the Admission Committee after the first year of study. A student who does not satisfy the admission conditions during the allotted time will be dropped from the Program.
4. **Enrollment projection –** We believe that the revised Ph.D. in Chemistry program will be attractive to students who in the past might have been inclined to pursue graduate studies in our program but decided not to apply or upon admission not enroll

due to the large numbers of required credits and non-credits requirments. Since we offer a Ph.D. in Chemistry Program where students with a B.S. in Chemistry do not have to obtain first a M.S. in Chemistry to obtain a Ph.D. degree (the standard in this academic field), the majority of students admitted to the program pursue directly the Ph.D. degree. In the proposed revision of the Ph.D. in Chemistry Program (vide infra) when a student that is pursuing the Ph.D. degree passes the requirements equivalent to the M.S. degree, except the thesis, the program will confer the M.S. degree to this student. In addition, all students with a B.S. in Chemistry that enter the program and do not specify that they are pursuing a M.S. degree will be classified as Ph.D. students and if they do not pass the candidacy exam, then they will be reclassified as a M.S. student. Therefore, in summary, the projection of students that each year will enroll in the Ph. D. in Chemistry Program is around 8-12 students in the initial 5-year period, and 15-20 in the next 5-year period.

G. Faculty

The 15 professors that currently are part of the Chemistry Graduate Program faculty will be the professors that will participate in the proposed revised Ph.D. in Chemistry Program. The Department of Chemistry is currently recruiting an Organic Chemistry research professor and an Analytical Chemistry research professor. Both professors will also be part of the Chemistry Graduate Program faculty and will participate in the revised Ph.D. in Chemistry Program.

Table 10 list the professors currently in the Chemistry Graduate Program.

H. Administration of the Program

The Coordinator of the Chemistry Graduate Program currently administers the M.S. and Ph.D. in Chemistry programs and will administer the proposed revised Ph.D. in Chemistry program. An administrative assistant from the Office of Graduate Studies and Research of the College of Natural Sciences is assigned to provide administrative assistance to all programs in the Chemistry Graduate Program and will continue to do so for the proposed revised Ph.D. in Chemistry Program. The Chemistry Graduate Program has an Admissions Committee, and Graduate Affairs Committee, a Curriculum Committee, an Academic Affairs Committee, and a Student Learning Assessment Committee.

I. Information resources

Students and professor in the Chemistry Graduate Program have access to hundreds of chemistry journals and books through the College of Natural Sciences Library. The University of Puerto Rico has a contract with the American Chemical Society (ACS) that gives free access to papers in the dozens of journals that ACS publishes. In addition, SciFinder is also provided. SciFinder, produced by Chemical Abstracts Service (CAS), a Division of the American Chemical Society, is the most comprehensive database for the chemical literature, searchable by topic, author, substances by name or CAS Registry Number, or by the use of the editor to draw chemical structures, substructures, or reactions.

The Program, through the Néstor Rodríguez Rivera Library of the College of Natural Sciences, has access to 1,730 bibliographic resources whose specific subject is Chemistry and 2,996 bibliographic resources whose general subject is related to chemistry. In addition, we have 450 journals in Chemistry and a total of 5,260 journals in the Sciences. There is also access to the Directory of Open Access Journals (DOAJ) which has 377 journals in Chemistry. On the other hand, the Library System catalog provides access to the Catalog of the Medical Sciences Campus with 375 general bibliographic resources in Chemistry and to the Mayagüez Campus catalog with 2,900 bibliographic resources whose specific subject is Chemistry. In electronic resources we have had 16 databases altogether, but the total per year fluctuates between 8 and 11. Among those bibliographic resources are those of ACS Publications, Annual Reviews, Elsevier, SciFinder, Springer, Web of Science and Wiley. The most recently acquired electronic resources are Annual Reviews, Cambridge University Press, Chicago University Press, Institute of Physics, Oxford Unviersity Press, SAGE, SciFinder, SIAM, Springer, Taylor & Francis and Wiley.

J. Teaching, research and service infrastructure

The Chemistry Graduate program has one assigned classroom available at the Facundo Bueso building (FB-266), but also has access to classroom in the College of Natural Sciences building. The research laboratories are located in three different building: the Facundo Bueso building, the building of the College of Natural Sciences

and the off-campus Molecular Sciences Research Center. The Molecular Sciences Research Center has one of the most advance scientific instrumentation facilities in the Caribbean. All laboratories have a current Chemistry Hygiene and Safety Plan and the professors have the required explosives license from the Puerto Rico Police Department.

K. Student services

1. Student services and support systems: Apart from the student services obtained from the Coordinator of the Chemistry Graduate Program, all other student services are provided through the Office of Graduate Studies and Research of the College of Natural Sciences (CNS) and the Office of the Department of Chemistry, both located in the CNS building, as well as the Deanship of Graduate Studies and Research and the different campus-wide offices such as Deanship of Academic Affairs, Deanship of Students, Registrar Office, Students' Ombusperson, Medical Services Facilities, and the Department of Counseling for the Student Development (DCODE), among others. Those services include admissions, enrollment, economic assistance, medical services, professional counseling and psychological services, and library services, among others.
2. Economic assistance – Students in the program are eligible to the Formative Academic Experience Program (PEAF) of the Deanship of Graduate Studies and Research, which provides stipends of $810 monthly for M.S. students for 10 months of the academic year. Students are also eligible to fellowships offered by the Deanship of Graduate Studies and Research and federal programs sponsored by NSF, NIH, NASA, DOE, some of the through programs on campus that opened thanks to successful grant applications to those federal agencies. Some of those program are the Puerto Rico Louis Stokes Alliance for Minority Participation Bridge to the Doctorate Fellowship (PR-LSAMP), the Puerto Rico Space Partnership for Research Innovation and Training PR-SPRInT), the NSF-PREM Center for Interfacial Electrochemistry of Energy Materials (CIE^2M), the NSF-CREST Center for Innovation, Research and Education in Environmental Nanotechnology ($CIRE^2N$), and the Research Training Initiative for Student Enhancement (RISE) Program.

L. Catalog and promotion

The program is promoted with the flyer of the Chemistry Graduate Program, the campus webpages and the Facebook pages of the Department of Chemistry and the College of Natural Science. The Catalog of courses for the M.S. in Chemistry Program is currently available to all interested students in the webpage of the Deanship of Graduate Studies and Research.

M. Budget Plan

Currently the Chemistry Graduate Program has no budget assigned to it in the annual budget of the Department of Chemistry or the College of Natural Sciences. All expenses to run the program are covered by the Department of Chemistry budget. A line item in the Department of Chemistry budget for travel is reserved for use by the Chemistry Graduate Program to cover the travel expenses of the speakers invited to participate in our Graduate Seminar Series. We would also like also for the line item in the Department of Chemistry budget for solvents, dry ice, gas tanks and liquid nitrogen be reserved for use by Chemistry Graduate Program.

The most recent self-study of the current M.S. and Ph.D. programs, which covered the academic years 2009-2010 to 2014-2015, described the lack of a separate budget for the Chemistry Graduate Program as a weakness of the program. Six years later, this is still the case. The program is embarked right now in a new self-study that will cover the period 2015-2016 to 2019-2020 and it will describe that this weakness remains.

Since all funds needed to run the program come out of the assigned budget to the Department of Chemistry, **this proposal for revision of the M.S. and Ph.D. programs and the establishment of a new M.A. program will have no budget impact**.

However, it is important to note that the Department of Chemistry has identified the need for new faculty, to replace professors who recently retired. Five years ago the program had 20 professors and now it has 15, so there is a need for funds for the Department of Chemistry to hire five (5) new tenure-track professors, all of which will be part of the Chemistry Graduate Program.

In the most recent Faculty Recruitment Plan of the Río Piedras Campus of the University of Puerto Rico (2019), permission to recruit only one Organic Chemistry Professor was requested. However, the Department of Chemistry had requested permission to hire five (5) new tenure-track professors. Therefore, four more professor are needed. Recently, the Department of Chemistry advertised an open position for an Analytical Chemistry Professor specialized in battery research with start-up funds provided by an NSF CREST grant.

N. Assessment of the program and Student Learning Assessment Plan

1. Development Plan - The Chemistry Graduate Program has a five-year development plan submitted in 2016 that will be updated in September of 2021 as part of the response to the self-study evaluation of the program currently underway. Every five years we administer a questionnaire to current students, alumni and professors of the program. The information obtained is used to assess the current program and propose any necessary changes. Part of the justification to embark in the preparation of this proposal was the results of the last questionnaire from 2015-2016.

   The next five-year development plan due in September 2021 will include ways to assess the implementation of the approved revisions of the M.S. and Ph.D. programs and the establishment of the new M.A. program.

2. Student Learning Assessment Plan

   The Student Learning Assessment Plan of the Chemistry Graduate Program is based on the development of established learning domains for all students on campus, which currently includes the graduate students in our two. programs (M.S. and Ph.D.) and will include the revised Ph.D. and M.S. programs and the new M.A. program when approved. The development of those learning domains among the students in these programs will allow them, at the end of their graduate studies, to fulfill the new Ph.D. alumnus profile. (Appendix 2c). The assessment plan uses an evaluation model of the UPR Division of Institutional Research and Assessment (DIRA) of the Deanship of Academic Affairs. The assessment is based on certain learning domains with their learning objectives and the courses where they will be evaluated to access student learning in each of those domains. In the first semester of the 2019-2020 Academic Year the program submitted the required three-year and annual plans (see tables of the three-year plan and the Annual Assessment

Plan submitted and approved by the DIRA). These tables will be used as part of the Assessment Plan for both the M.A., M.S. and the Ph.D. programs. We will use the online OLAS system for these assessments. The annual reports will be shared with the entire Program's faculty and an action plan will be established to correct identified problem areas. The student learning assessment information will be used to assess how the program is fulfilling its student learning goals as well as the graduate program development goals. Table 21 shows a summary of the three-year plan, which is presented in Table 22. Table 23 is the annual assessment plan.

Table 21. Summary of the three-year plan (2019-2022): Student Learning Domains to be evaluated each academic year (Graduate Level).

Learning Domains	2019-2020	2020-2021	2021-2022
1. Information skills		X	X
2. Effective communication	X	X	X
3. Discipline content (Technology integration; Team work)	X	X	X
4. Research and creation	X	X	X
5. Critical thinking (Continuous learning)	X	X	X
6. Social responsibility (Ethical Sensibility; Leadership)		X	X

Table 22. Three-year assessment plan (2019-2022): Student learning domains to be evaluated each academic year (Graduate Level).

Academic year	Domains to evaluate	Learning objectives	Course where they will be evaluated
2019-2020	**2. Effective communication**	(a) Effectively communicate the fundamentals of their discipline to the scientific community and diverse groups in a clear and logical way. (b) Demonstrate technical ability to make presentations (in terms of quality and organization of ideas, ability to argue, quality of visual media, personal projection, and time management) to a diverse community in Spanish and English. (c) Write publishable research (articles and a dissertation) in Spanish and/or English.	1. Proposal A 2. Graduate Seminar
	3. Discipline content (Technology integration; Teamwork)	(a) Demonstrate mastery of the fundamental concepts of Chemistry. (b) Apply the concepts of Chemistry to solve theoretical and practical problems that require an interdisciplinary approach. (c) Know and critically evaluate the literature and scientific methodology and use the information obtained in solving problems. (d) Incorporate current instrumentation and technological resources as support tools in the design of experiments and in problem solving. (e) Demonstrate collaborative research actions by working in multi, inter- and transdisciplinary teams.	1. Proposal A 2. Graduate Seminar

	4. Research and creation	Carry out scientific, creative, critical and innovative research, to offer solutions and generate knowledge framed in the ethical - professional commitment.	1. Proposal A 2. Graduate Seminar
	5. Critical thinking (Continuos learning)	(a) Know and critically evaluate the literature and scientific methodology and use the information obtained in solving problems; (b) Exercise independence of judgment and show creativity and initiative to contribute to the solution of issues and problems related to Chemistry and the sciences, arts and enterprises related to it. (c) Demonstrate the ability to keep up with knowledge through continuous learning.	1. Proposal A 2. Graduate Seminar

Academic year	Domains to evaluate	Learning objectives	Course where they will be evaluated
2020-2021	**1. Information skills**	(a) Know the scientific literature and handle the information in a critical, effective and ethical way to solve problems. (b) Correctly handle the scientific literature to support the solution of chemical problems.	1. Proposal A 2. Graduate Seminar 3. Proposal B
	2. Effective communication	(a) Effectively communicate the fundamentals of their discipline to the scientific community and diverse groups in a clear and logical way. (b) Demonstrate technical ability to make presentations (in terms of quality and organization of ideas, ability to argue, quality of visual media, personal projection, and time management) to a diverse community in Spanish and English. (c) Write publishable research (articles and a dissertation) in Spanish and/or English.	1. Proposal A 2. Graduate Seminar 3. Proposal B
	3. Discipline content (Technology integration; Teamwork)	(a) Demonstrate mastery of the fundamental concepts of Chemistry. (b) Apply the concepts of Chemistry to solve theoretical and practical problems that require an interdisciplinary approach. (c) Know and critically evaluate the literature and scientific methodology and use the information obtained in solving problems. (d) Incorporate current instrumentation and technological resources as support tools in the design of experiments and in problem solving. (e) Demonstrate collaborative research actions by working in multi, inter- and transdisciplinary teams.	1. Proposal A 2. Graduate Seminar 3. Proposal B
	4. Research and creation	Carry out scientific, creative, critical and innovative research, to offer solutions and generate knowledge framed in the ethical - professional commitment.	1. Proposal A 2. Graduate Seminar 3. Proposal B
	5. Critical thinking (Continuos learning)	(a) Know and critically evaluate the literature and scientific methodology and use the information obtained in solving problems; (b) Exercise independence of judgment and show creativity and initiative to contribute to the solution of issues and problems related to Chemistry and the sciences, arts and enterprises related to it. (c) Demonstrate the ability to keep up with knowledge through continuous learning.	1. Proposal A 2. Graduate Seminar 3. Proposal B
	6. Social responsibility (Ethical Sensibility; Leadership)	(a) Show ethical behavior in their academic performance. (b) Show commitment to the protection of natural, environmental and cultural resources through the best practices of chemistry and occupational safety and environmental protection standards. (c) Show respect for human rights through actions of social inclusion and commitment to diversity.	1. Proposal A 2. Graduate Seminar 3. Proposal B

Academic year	Domains to evaluate	Learning objectives	Course where they will be evaluated
		(d) Integrate theories, practical protocols that protect the environment and ethical and safety codes to their professional or investigative work. (e) Know the scientific literature and handle the information in a critical, effective and ethical way to solve problems. (f) Assume and promote leaderships that contribute to individual and collective transformations.	

Academic year	Domains to evaluate	Learning objectives	Course where they will be evaluated
2021-2022	**1. Information skills**	(a) Know the scientific literature and handle the information in a critical, effective and ethical way to solve problems. (b) Correctly handle the scientific literature to support the solution of chemical problems.	1. Proposal A 2. Graduate Seminar 3. Proposal B 4. Thesis/ Dissertation Defense
	2. Effective communication	(a) Effectively communicate the fundamentals of their discipline to the scientific community and diverse groups in a clear and logical way. (b) Demonstrate technical ability to make presentations (in terms of quality and organization of ideas, ability to argue, quality of visual media, personal projection, and time management) to a diverse community in Spanish and English. (c) Write publishable research (articles and a dissertation) in Spanish and/or English.	1. Proposal A 2. Graduate Seminar 3. Proposal B 4. Thesis/ Dissertation Defense
	3. Discipline content (Technology integration; Teamwork)	(a) Demonstrate mastery of the fundamental concepts of Chemistry. (b) Apply the concepts of Chemistry to solve theoretical and practical problems that require an interdisciplinary approach. (c) Know and critically evaluate the literature and scientific methodology and use the information obtained in solving problems. (d) Incorporate current instrumentation and technological resources as support tools in the design of experiments and in problem solving. (e) Demonstrate collaborative research actions by working in multi, inter- and transdisciplinary teams.	1. Proposal A 2. Graduate Seminar 3. Proposal B 4. Thesis/ Dissertation Defense
	4. Research and creation	Carry out scientific, creative, critical and innovative research, to offer solutions and generate knowledge framed in the ethical - professional commitment.	1. Proposal A 2. Graduate Seminar 3. Proposal B 4. Thesis/ Dissertation Defense
	5. Critical thinking (Continuos learning)	(a) Know and critically evaluate the literature and scientific methodology and use the information obtained in solving problems; (b) Exercise independence of judgment and show creativity and initiative to contribute to the solution of issues and problems related to Chemistry and the sciences, arts and enterprises related to it. (c) Demonstrate the ability to keep up with knowledge through continuous learning.	1. Proposal A 2. Graduate Seminar 3. Proposal B 4. Thesis/ Dissertation Defense

	6. Social responsibility (Ethical Sensibility; Leadership)	(a) Show ethical behavior in their academic performance. (b) Show commitment to the protection of natural, environmental and cultural resources through the best practices of chemistry and occupational safety and environmental protection standards. (c) Show respect for human rights through actions of social inclusion and commitment to diversity. (d) Integrate theories, practical protocols that protect the environment and ethical and safety codes to their professional or investigative work. (e) Know the scientific literature and handle the information in a critical, effective and ethical way to solve problems. (f) Assume and promote leaderships that contribute to individual and collective transformations.	1. Proposal A 2. Graduate Seminar 3. Proposal B 4. Thesis/ Dissertation Defense

Table 23 shows the annual student learning assessment plan.

Table 23. Annual student learning assessment plan.

FIRST SEMESTER					
Learning Domain in the Campus Mission	**Course used to gather information**	**Learning objectives**	**Evaluation criteria** (Rubric)	**Transformative Actio to be implemented during the first semester** (Consider the findings from the previous cycle)	**Expected achievements** (Metrics)
Effective Communication	1. Proposal A 2. Graduate Seminar	(a) Effectively communicate the fundamentals of their discipline to the scientific community and diverse groups in a clear and logical way. (b) Demonstrate technical ability to make presentations (in terms of quality and organization of ideas, ability to argue, quality of visual media, personal projection, and time management) to a diverse community in Spanish and English. (c) Write publishable research (articles and a dissertation) in Spanish and/or English.	*Thesis Seminar Presentation Rubric:* *Overall breadth of knowledge* Presentation is superior Presentation reveals exceptional depth of subject of knowledge Presentation reveals the ability to interconnect and extend knowledge from multiple disciplines *Quality of oral communication* **U**se and knowledge of technical terminology and concepts is excellent Oral expressions is excellent Organization of ideas is excellent *Overall quality of presentation* Well organized Professional presentation Excellent communication skills Slides and handouts outstanding	We have been able to identify that, since we give every first semester of each academic year a seminar on the presentation of Proposal A, we can emphasize in that seminar the aspects of the evaluation criteria in which students are not meeting expectations more frequently..	Expected Achievement: 70% of students will average between *meets* and *exceeds expectations* based on the rubric.
Research and creation	1. Proposal A 2. Graduate Seminar	Carry out scientific, creative, critical and innovative research, to offer solutions and generate knowledge framed in the ethical - professional commitment.	*Thesis Seminar Presentation Rubric:* *Overall quality of science* *Overall quality of science* Objectives are well defined	Work is still being done to finalize the statistics and analysis of the assessment of student learning for the previous cycle. However, we can already identify that since we give all the first semesters of each academic year a	Expected Achievement: 70% of students will average between *meets* and *exceeds expectations* based on the rubric.

				seminar on the presentation of Proposal A, we can emphasize in that seminar the aspects of the evaluation criteria in which students are not meeting expectations more frequently.	
Discipline content	1. Proposal A 2. Graduate Seminar	(a) Demonstrate mastery of the fundamental concepts of Chemistry. (b) Apply the concepts of Chemistry to solve theoretical and practical problems that require an interdisciplinary approach. (c) Know and critically evaluate the literature and scientific methodology and use the information obtained in solving problems. (d) Incorporate current instrumentation and technological resources as support tools in the design of experiments and in problem solving. (e) Demonstrate collaborative research actions by working in multi, inter- and transdisciplinary teams.	*Thesis Seminar Presentation Rubric:* *Overall quality of science* Reflects mastery of subject matter and associated literature *Overall breadth of knowledge* Presentation reveals exceptional depth of subject knowledge Presentation reveals the ability to interconnect and extend knowledge from multiple disciplines *Quality of oral communication* **U**se and knowledge of technical terminology and concepts is excellent	Work is still being done to finalize the statistics and analysis of the assessment of student learning for the previous cycle. However, we can already identify that since we give all the first semesters of each academic year a seminar on the presentation of Proposal A, we can emphasize in that seminar the aspects of the evaluation criteria in which students are not meeting expectations more frequently.	Expected Achievement: 70% of students will average between *meets* and *exceeds expectations* based on the rubric.

Appendix 1. List of graduate level courses (as specified in the current Graduate Catalog)

Core courses:

CHEM 6011 – Theory of Inorganic Chemistry I
Credits: 3
Prerrequisites: CHEM 4041-4042 or its equivalent
Atomic structure and electronic configuration of the elements in relation to the periodic system, theory of the chemical bond; theory of acids and bases and coordination compounds.

CHEM 6012 – Theory of Inorganic Chemistry II
Credits: 3
Prerrequisites: CHEM 4041-4042 or its equivalent
Coordination compounds.

CHEM 6215 – Theory of Analytical Chemistry
Credits: 3
Prerrequisites: CHEM 3255, 4042 or its equivalent
Theoretical study of chemical equilibrium, separations and electrochemical methods. Discussion of statistical methods in measurement and experimental work.

CHEM 6225 – Theory of Instrumental Analysis
Credits: 3
Prerrequisites: CHEM 3255, 4041 or its equivalent
Theory of instrumental analysis methods and techniques including discussion of visible and ultraviolet, infrared, atomic absorption spectroscopies and nuclear magnetic resonance, mass spectrometry, gas chromatography, high performance liquid chromatography, potentiometry, polarography, voltammetry, surface analysis and automated analysis.

CHEM 6411 – Theory of Organic Chemistry I
Credits: 3
Prerrequisite: CHEM 3032 or its equivalent
Study and description of mechanisms of organic reactions. Chemical bond and molecular structure. Hückel and frontier molecular orbitals. Pericyclic reactions, Woodward-Hoffmann rules, organic photochemistry and radical reactions. Stereochemistry. Linear free energy relationships. The Hammet equation and transition state theory. Isotopic effects.

CHEM 6412 – Theory of Organic Chemistry II
Credits: 3
Prerrequisite: CHEM 3032 or its equivalent
Study and description of mechanisms of organic reactions. Chemical bond and molecular structure. Hückel and frontier molecular orbitals. Pericyclic reactions, Woodward-Hoffmann rules, organic photochemistry and radical reactions.

Stereochemistry. Linear free energy relationships. The Hammet equation and transition state theory. Isotopic effects.

CHEM 6611 – Theory of Physical Chemistry I (3 credits)
Credits: 3
Prerrequisite: CHEM 4042
Study of the laws and principles of theoretical chemistry.

CHEM 6612 – Theory of Physical Chemistry II
Credits: 3
Prerrequisite: CHEM 4042
Study of the laws and principles of theoretical chemistry.

CHEM 6811 – Advanced Biochemistry I
Credits: 3
Prerrequisite: CHEM 4042
Study of the chemistry and reactions of the constituents of living matter and the mechanisms and regulation of the most important biological processes.

CHEM 6812 – Advanced Biochemistry II
Credits: 3
Prerrequisite: CHEM 4042
Study of the chemistry and reactions of the constituents of living matter and the mechanisms and regulation of the most important biological processes.

Advanced and Elective Courses in Chemistry

CHEM 6235 – Instrumental Analysis Laboratory
Credits: 2
Prerrequisites: CHEM 3255, 6225 or taking them concurrently
Analytical techniques and methods. Series of illustrative experiments of the methods whose theoretical foundations have been discussed in QUIM 6225.

CHEM 6813 – Biochemistry Techniques
Credits: 3
Discussion and application of the fundamental techniques in the field of biochemistry.

CHEM 6825 – Biochemistry of Organized Systems
Credits: 3
Prerrequisites: CHEM 4041 or its equivalent. CHEM 4055 or its equivalent is recommended.
The chemical and physical properties of macromolecules and their interactions in biological systems. Reaction kinetics and mechanism in biochemical systems.

CHEM 6896 – Continuation of Master's Thesis
Credit: 0

This course will allow those Master's students who have completed all of their course credits to maintain active status in the Program while completing their thesis work.

CHEM 6905 – Chemical Principles and Practices I
Credits: 3
Limited to graduate students from the Department of Chemistry.
Discussion of chemical principles with special emphasis on their application to laboratory work and its evaluation.

CHEM 6906 – Chemical Principles and Practices II
Credits: 3
Limited to graduate students from the Department of Chemistry.
Discussion of chemical principles with special emphasis on their application to laboratory work and its evaluation.

CHEM 6999 – Master's Thesis Research
Credits: 1-6
Research work, under the direction of a research advisor.

CHEM 8005 – Seminar in Inorganic Chemistry I
Credits: 2
Discussion of recent advances in Inorganic Chemistry.

CHEM 8006 – Seminar in Inorganic Chemistry II
Credits: 2
Discussion of recent advances in Inorganic Chemistry.

CHEM 8015 – Physical Inorganic Chemistry
Credits: 3
Prerrequisite: CHEM 6012
Mechanism of reactions in inorganic systems, with emphasis on coordination compounds.

CHEM 8025 – Ligand Field Theory
Credits: 3
Prerrequisite: CHEM 6012
Bond theory and spectra in coordination compounds.

CHEM 8035 – Structural Methods in Inorganic Chemistry
Credits: 3
Prerrequisite: CHEM 6011
Study of spectroscopic, diffraction and magnetic resonance methods for determining the structure of inorganic and organometallic compounds.

CHEM 8045 – Organometallic Compounds of Main Group Elements

Credits: 3
Prerrequisites: CHEM 6012, 6412
Presentation of the structure and properties of the main organometallic compounds, their preparation, reactions and applications to organic synthesis.

CHEM 8046 – Organometallic Compounds of Transition Metals
Credits: 3
Prerrequisites: CHEM 6011, 6411
Presentation of the structure and reactions of transition metal complexes, within the context of catalysis in organic synthesis.

CHEM 8205 – Seminar in Analytical Chemistry I (2 credits)
Credits: 2
Discussion of recent advances in Analytical Chemistry.

CHEM 8206 – Seminar in Analytical Chemistry II (2 credits)
Credits: 2
Discussion of recent advances in Analytical Chemistry.

CHEM 8211 – Advance Analytical Chemistry I
Credits: 3
Prerrequisito: CHEM 6225
Study of the applications of chemical and instrumental methods to the analysis of chemical problems.

CHEM 8212 – Advance Analytical Chemistry II
Credits: 3
Prerrequisito: CHEM 6225
Study of the applications of chemical and instrumental methods to the analysis of chemical problems.

CHEM 8405 – Seminar in Organic Chemistry I
Credits: 2
Discussion of recent advances in Organic Chemistry.

CHEM 8406 – Seminar in Organic Chemistry II
Credits: 2
Discussion of recent advances in Organic Chemistry.

CHEM 8415 – Physical Organic Chemistry
Credits: 3
Prerrequisites: CHEM 6411-6412, 6611-6612.
The methods of thermodynamics, kinetics and quantum chemistry are treated in detail and applied to mechanisms of organic reactions. These include linear free energy relationships, substituent effects, isotopic effect, surface energy, electronic structure of reaction intermediates, and symmetry arguments for molecular orbitals.

CHEM 8425 – Synthetic Organic Chemistry
Credits: 3
Prerrequisites: CHEM 6411-6412
Study of the multistep synthesis of both natural and non-natural products. General strategies using retrosynthetic analyzes and synthetic equivalents for molecular construction are examined. The stereochemical control is examined from the standpoint of the substrate and the reactant. Select transformations are studied from a mechanistic point of view, particularly within the context of chirality transfer in asymmetric processes.

CHEM 8435 – Natural Products
Credits: 3
Prerrequisites: CHEM 6411-6412
Structure elucidation, partial and total synthesis and biogenesis of natural products. Specific examples of terpenes, steroids, alkaloids, proteins, lipids and pigments. The elucidation of the structures involves classical methods as well as modern spectroscopic methods.

CHEM 8445 – Estructural Problems in Organic Chemistry
Credits: 3
Prerrequisites: CHEM 6411-6412
Study of the spectroscopic elucidation of the structure of organic compounds and reaction intermediates. The spectroscopic methods presented are visible ultraviolet, infrared, nuclear and electronic magnetic resonance, and diffraction methods. The basis and application of these are discussed and practiced with specific examples. The course does not delve into aspects of quantum mechanics.

CHEM 8605 – Seminar in Physical Chemistry I
Credits: 2
Discussion of recent advances in Physical Chemistry.

CHEM 8606 – Seminar in Physical Chemistry II
Credits: 2
Discussion of recent advances in Physical Chemistry.

CHEM 8615 – Chemical Kinetics
Credits: 3
Prerrequisite: CHEM 4042
Study of the theory and applications of the kinetics of chemical reactions in the gas and liquid phase.

CHEM 8625 – Introduction to Molecular Spectroscopy
Credits: 3
Prerrequisites: CHEM 6611-6612.

Molecular and quantum mechanical spectroscopy, with particular attention to the molecular structure and the deduced symmetry of the vibrational and rotational spectra. Includes the calculation of thermodynamic functions starting from spectroscopic data.

CHEM 8635 –Statistical Thermodynamics
Credits: 3
Prerrequisites: CHEM 6611-6612
Introduction to statistical mechanics. Study of the relationships between the thermodynamic functions of gases, liquids and solids and their molecular structures.

CHEM 8645 – Quantum Chemistry
Credits: 3
Prerrequisites: CHEM 6611-6612
The basic principles of quantum mechanics and its applications to chemical problems. It includes wave motion, matrices, atomic and molecular structure and spectra, the quantum theory of valence, and the phenomenon of resonance.

CHEM 8801 – Seminar in Biochemistry I
Credits: 2
Discussion of recent advances in Biochemical Chemistry.

CHEM 8802 – Seminar in Biochemistry II
Credits: 2
Discussion of recent advances in Biochemical Chemistry.

CHEM 8885 – Enzymatic Catalysis
Credits: 3
Prerrequisite: CHEM 6811
The study of protein chemistry with an emphasis on conformations and their effect on enzymatic catalysis. It includes inhibition of enzymatic catalysis, modifications and mechanisms.

CHEM 8896 – Continuation of Doctoral Dissertation
Credit: 0
This course allows those students who have completed all of their course credits to remain active as students in the Doctoral Program while completing their thesis work.

CHEM 8896 – Candidacy Exam
Credits: 0

CHEM 8901 – Graduate Seminar I

CHEM 8902 – Graduate Seminar II
Credits: 1

Seminar on topics of interest in chemistry presented by students, faculty members, and visiting professors.

CHEM 8990 – Special Topics in Inorganic Chemistry
Credits: 1-4
Study and discussion of various topics in the field of inorganic chemistry. These include bioinorganic chemistry and symmetry rules for inorganic reactions.

CHEM 8992 – Special Topics in Analytical Chemistry
Credits: 1-4
Advanced study of specialized topics in analytical chemistry such as signal processing, interfaces, environmental analysis and electrode processes.

CHEM 8994 – Special Topics in Organic Chemistry
Credits: 1-4
Advanced study of specialized topics in organic chemistry, such as the biosynthesis of natural products, boron compounds in organic synthesis and total synthesis.

CHEM 8996 – Special Topics in Physical Chemistry
Credits: 1-4
Advanced study of specialized topics in physical chemistry such as photochemistry, photophysical processes, dynamics of molecular reactions and resonance spectroscopy.

CHEM 8998 – Special Topics in Biochemistry
Credits: 1-4
Advanced study of specialized topics in biochemistry such as lipids in membranes, protein conformation and signal transduction.

CHEM 8999 – Research for the Doctoral Dissertation
Credits: 1-12
Students will work on their dissertation under the supervision of their thesis advisor (s).

Appendix 2.

a. Alignment of the proposed revised M.S. in Chemistry Program alumnus profile of the Chemistry Graduate Program with the Graduate Student Alumnus Profile of the Río Piedras Campus – Certification No. 104, 2016-2017, of the Academic Senate.

Provisions of the Campus' Graduate Student AlumnusProfile	Provisions of the M.S. in Chemistry Program Alumnus Profile
Carry out research or projects in order to create, offer solutions or generate knowledge.	To conduct creative, critical and innovative scientific research to offer solutions and generate knowledge framed in an ethical-professional commitment as learned through problem solving based learning strategies in the program.
Critically evaluate knowledge from a variety of theoretical and methodological approaches.	To know and critically evaluate the scientific literature and methodology and use the obtained information in problem solving.
Exercise independence of judgment and show creativity and initiative.	To exercise independence of opinion and show creativity and initiative to contribute to the solution of matters and problems related to Chemistry and the sciences, arts, and enterprises related to it.
Integrate theories, practical protocols and codes of ethics to their professional or investigative work.	To integrate theories and practical protocols that protect the environment and ethical and security codes in his/her professional and research endeavors.
Handle information in a critical, effective and ethical manner.	To know the scientific literature and manage information in a critical, effective and ethical way for problem solving.
Incorporate technology in their professional and investigative work.	To incorporate current instrumentation and technological resources as resource tools in the design of experiments and in problem solving.
Effectively communicate the knowledge of your field or discipline of study.	To communicate effectively the fundamentals of his/her discipline to the scientific community and to diverse groups in a clear and logical manner.
Learn autonomously and continuously.	To show ability to apply knowledge, skills and scientific ethical conduct in solving real problems associated with the field of Chemistry that promotes scientific, social and economic development to improve the quality of life in Puerto Rico, the Caribbean and the world.

Show commitment to the protection and enrichment of natural and cultural heritages.	To demonstrate commitment to the protection of natural, environmental and cultural resources through best practices in Chemistry and occupational safety and environmental protection standards.
Demonstrate respect for human rights through actions of social inclusion and commitment to diversity.	To show respect for human rights through actions of social inclusion and commitment to diversity.
Demonstrate collaborative actions through multidisciplinary or interdisciplinary teamwork.	To demonstrate collaborative actions through multidisciplinary or interdisciplinary teamwork.
Assume and promote leaderships that contribute to individual and collective transformations.	To assume and encourage leadership roles that contribute to individual and collective transformations
	Mastering the concepts and fundamentals of Chemistry, its various applications in daily life and its relationship with other scientific disciplines.
	Mastering the technical skills required for the exercise of your profession as a Chemist.
	Show mastery of knowledge, competence in instrumentation and technical skills within their specialty in Chemistry.
	Identify important problems inherent to Chemistry and other disciplines to design effective strategies and / or experiments to solve them.

b. Alignment of the proposed new M.A. in Chemistry Program (no thesis) alumnus profile of the Chemistry Graduate Program with the Graduate Student Alumnus Profile of the Río Piedras Campus – Certification No. 104, 2016-2017, of the Academic Senate

Provisions of the Campus' Graduate Student AlumnusProfile	Provisions of the M.A. in Chemistry Program Alumnus Profile
Realizar investigaciones o proyectos con el fin de crear, ofrecer soluciones o generar conocimiento.	To conduct creative, critical and innovative scientific research to offer solutions and generate knowledge framed in an ethical-professional commitment as learned through problem solving based learning strategies in the program.
Evaluar críticamente el conocimiento desde una variedad de acercamientos teóricos y metodológicos.	To know and critically evaluate the scientific literature and methodology and use the obtained information in problem solving.
Ejercer independencia de criterio y mostrar creatividad e iniciativa.	To exercise independence of opinion and show creativity and initiative to contribute to the solution of matters and problems related to Chemistry and the sciences, arts, and enterprises related to it.
Integrar teorías, protocolos prácticos y códigos de éticas a su quehacer profesional o investigativo.	To integrate theories and practical protocols that protect the environment and ethical and security codes in his/her professional and research endeavors.
Manejar la información de manera crítica, efectiva y ética.	To know the scientific literature and manage information in a critical, effective and ethical way for problem solving.
Incorporar la tecnología en su quehacer profesional e investigativo.	To incorporate current instrumentation and technological resources as resource tools in the design of experiments and in problem solving.
Comunicar efectivamente los conocimientos de su campo o disciplina de estudio.	To communicate effectively the fundamentals of his/her discipline to the scientific community and to diverse groups in a clear and logical manner.
Aprender de forma autónoma y continua.	To show ability to apply knowledge, skills and scientific ethical conduct in solving real problems associated with the field of Chemistry that promotes scientific, social and economic development to improve the quality of life in Puerto Rico, the Caribbean and the world.
Mostrar compromiso con la protección y el enriquecimiento de los patrimonios naturales y culturales.	To demonstrate commitment to the protection of natural, environmental and cultural resources through best practices in

	Chemistry and occupational safety and environmental protection standards.
Demostrar respeto de los derechos humanos mediante acciones de inclusión social y compromiso con la diversidad.	To show respect for human rights through actions of social inclusion and commitment to diversity.
Demostrar acciones colaborativas mediante el trabajo en equipo multidisciplinario o interdisciplinario.	To demonstrate collaborative actions through multidisciplinary or interdisciplinary teamwork.
Asumir y fomentar liderazgos que contribuyan a transformaciones individuales y colectivas.	To assume and encourage leadership roles that contribute to individual and collective transformations
	Mastering the concepts and fundamentals of Chemistry, its various applications in daily life and its relationship with other scientific disciplines.
	Identify important problems inherent to Chemistry and other disciplines to design effective strategies and / or experiments to solve them.

c. Alignment of the proposed revised Ph.D. in Chemistry Program alumnus profile of the Chemistry Graduate Program with the Graduate Student Alumnus Profile of the Río Piedras Campus – Certification No. 104, 2016-2017, of the Academic Senate

Provisions of the Campus' Graduate Student AlumnusProfile	Provisions of the Ph.D. in Chemistry Program Alumnus Profile
Realizar investigaciones o proyectos con el fin de crear, ofrecer soluciones o generar conocimiento.	To conduct creative, critical and innovative scientific research to offer solutions and generate knowledge framed in an ethical-professional commitment as learned through problem solving based learning strategies in the program.
Evaluar críticamente el conocimiento desde una variedad de acercamientos teóricos y metodológicos.	To know and critically evaluate the scientific literature and methodology and use the obtained information in problem solving.
Ejercer independencia de criterio y mostrar creatividad e iniciativa.	To exercise independence of opinion and show creativity and initiative to contribute to the solution of matters and problems related to Chemistry and the sciences, arts, and enterprises related to it.
Integrar teorías, protocolos prácticos y códigos de éticas a su quehacer profesional o investigativo.	To integrate theories and practical protocols that protect the environment and ethical and security codes in his/her professional and research endeavors.
Manejar la información de manera crítica, efectiva y ética.	To know the scientific literature and manage information in a critical, effective and ethical way for problem solving.
Incorporar la tecnología en su quehacer profesional e investigativo.	To incorporate current instrumentation and technological resources as resource tools in the design of experiments and in problem solving.
Comunicar efectivamente los conocimientos de su campo o disciplina de estudio.	To communicate effectively the fundamentals of his/her discipline to the scientific community and to diverse groups in a clear and logical manner.
Aprender de forma autónoma y continua.	To show ability to apply knowledge, skills and scientific ethical conduct in solving real problems associated with the field of Chemistry that promotes scientific, social and economic development to improve the quality of life in Puerto Rico, the Caribbean and the world.
Mostrar compromiso con la protección y el enriquecimiento de los patrimonios naturales y culturales.	To demonstrate commitment to the protection of natural, environmental and cultural resources through best practices in

	Chemistry and occupational safety and environmental protection standards.
Demostrar respeto de los derechos humanos mediante acciones de inclusión social y compromiso con la diversidad.	To show respect for human rights through actions of social inclusion and commitment to diversity.
Demostrar acciones colaborativas mediante el trabajo en equipo multidisciplinario o interdisciplinario.	To demonstrate collaborative actions through multidisciplinary or interdisciplinary teamwork.
Asumir y fomentar liderazgos que contribuyan a transformaciones individuales y colectivas.	To assume and encourage leadership roles that contribute to individual and collective transformations
	Mastering the concepts and fundamentals of Chemistry, its various applications in daily life and its relationship with other scientific disciplines.
	Mastering the technical skills required for the exercise of your profession as a Chemist.
	Show mastery of knowledge, competence in instrumentation and technical skills within their specialty in Chemistry.
	Identify important problems inherent to Chemistry and other disciplines to design effective strategies and / or experiments to solve them.
	Show ability to apply knowledge, skills and scientific ethical conduct in solving real problems associated with the field of Chemistry that promotes scientific, social and economic development to improve the quality of life in Puerto Rico, the Caribbean and the world.