Department of Chemistry
Outcomes Assessment

The Chemistry Department at the University of Rhode Island offers three undergraduate degrees: the Bachelor of Science in Chemistry, the Bachelor of Arts in Chemistry, and the Bachelor of Science in Chemistry and Chemical Oceanography. The BS degrees are more scientifically intensive than the BA degree, so require more chemistry courses. The BA degree in Chemistry is typically earned as a second major by students, coupled with secondary education, biology (often pre-medical students), or pharmacy.

The degree programs for Chemistry majors are based upon the requirements set forth by the American Chemical Society (ACS). The ACS Committee on Professional Training (CPT) is the accrediting body for Chemistry degrees. Both industry and graduate schools recognize that students with an ACS certified degree have succeeded in a high quality program and have earned a valuable personal credential in the field of Chemistry. The BS in Chemistry is the ACS accredited degree at URI. The BS in Chemistry and Chemical Oceanography and the BA in Chemistry are not accredited, but are guided by the CPT mandates.

Curriculum Objectives

The curriculum set by the CPT is divided into three parts: core courses, advanced courses, and laboratory. Each of these areas will be discussed separately below. The chemistry degree also requires ancillary courses in mathematics and physics for preparation for upper level courses.

The core curriculum consists of basic instruction, at a minimum of 28 semester credits, in the areas of analytical chemistry, inorganic chemistry, organic chemistry, and calculus-based physical chemistry. URI meets the core curriculum with the following courses: CHM 191 & CHM 192 (general chemistry & inorganic); CHM 212 (analytical); CHM 226, CHM 227, & CHM 228 (organic); CHM 335, and CHM 431, & CHM 432 (physical). These courses account for 30 credits towards a student degree. The core curriculum includes 226 hours of laboratory work. Finally, the core curriculum includes 1 year of calculus and 1 year of physics with laboratory.

BS Degree in Chemistry (accredited by ACS)

The CPT requires a minimum of nine additional credits of advanced courses that build upon the core requirements and which includes a biochemistry component. This minimum is exceeded in the Chemistry B.S. degree at URI. CHM 401 & CHM 402 build upon inorganic and physical chemistry, CHM 412 & CHM 414 build upon analytical chemistry, CHM 425 & CHM 427 build upon organic chemistry, and CHM 441 introduces biochemistry from a physical chemistry perspective. Finally, CHM 492 is a one-credit seminar course that gives the student experience in oral presentation of a chemistry topic. These courses provide the student an additional 19 credits toward their degree.

The CPT also requires additional mathematics and physics for the accredited degree. These are met at URI by one more year of calculus and one additional semester of physics with laboratory.

The CPT mandates at least 500 hours of laboratory work for the certified degree. CHM 191 (general chemistry), CHM 192 (general chemistry), and CHM 212 (quantitative analysis) all have a laboratory component as part of the course. CHM 226 (organic chemistry), CHM 335 (physical chemistry), CHM 402 (physical inorganic chemistry), CHM 414 (instrumental analysis), and CHM 425 (qualitative organic chemistry) are solely laboratory courses. The student can synthesize all of the various chemistry topics when doing research in CHM 353 & CHM 354. The research courses draw upon all of the student's previous study, although the emphasis will change depending upon the research problem chosen. All laboratory courses encompass some or all of the following activities: keeping experimental records; synthesis of compounds; performance of accurate and precise measurements; use of modern instrumentation; interpretation of experimental results; statistical analysis of data; anticipation and recognition of chemical hazards; design of experiments; use of the literature to plan and execute experiments; communication of results using oral and written reports; and the ability to work in small teams. The BS degree encompasses more than 740 hours of laboratory work, including the research component.

Working independently on a research project and reporting the results are amongst the best ways for students to integrate what they have learned. At URI, these activities are embodied in CHM 353, CHM 354, and CHM 492. CHM 353 and CHM 354 are research courses where the student works with a faculty member, graduate students, or other undergraduates to investigate a problem with an unknown solution. The student is required to write a report detailing the results of the investigation. The report is written in the style of a journal article, so it includes an Introduction section, an Experimental section, a Results and Discussion section, a Conclusion, and literature references. Research requires the student to integrate the knowledge they have learned from previous lecture and laboratory coursework. This capstone experience forces the student to embody all of the qualities of a working chemist. CHM 492 is a seminar course that requires the student to present a full-length seminar on a topic of the student's choice. Typically, this will be an oral presentation of the student's research project. Oral communication of chemistry and the ability to answer questions in the seminar environment is another critical skill that integrates student learning.

The full curriculum for the BS degree in Chemistry is summarized on the attached spreadsheet.

BA in Chemistry

The BA degree is designed for students that have dual degree objectives. Many science curricula require one year of general chemistry and one year of organic chemistry with laboratory, a total of 16 credits of chemistry. This is, essentially, half of the BA degree. The four additional chemistry courses in the core curriculum provide a firm background across the field of chemistry for the BA student. One additional advanced course (chosen from CHM 401, CHM 412, CHM 427, or CHM 441) that meets the student's interest completes the BA degree.

The full curriculum for the BA degree in Chemistry is summarized on the attached spreadsheet.

BS in Chemistry and Chemical Oceanography

The BS in Chemistry and Chemical Oceanography has the same requirements as the BS in Chemistry with the following exceptions: CHM 353 and CHM 354 (Research in Chemistry) are replaced by OCG 493 and OCG 494 (Independent Study in Oceanography) and CHM 402 (Advanced Inorganic Laboratory), CHM 441 (Chemistry of Biological Systems), and CHM 492 (Seminar in Chemistry) are replaced by OCG 451 (Oceanographic Science) and OCG 521 (Chemical Oceanography). This gives the student the full core curriculum in chemistry, most of the advanced courses, and a solid introduction into the field of chemical oceanography.

The full curriculum for the BS degree in Chemistry and Chemical Oceanography is summarized on the attached spreadsheet.

BS in Chemistry and Forensic Chemistry

The BS in Chemistry and Forensic Chemistry has the same requirements as the BS in Chemistry with the following exceptions: CHM 353 (Research in Chemistry) is replaced by CHM 354 (Research in Forensic Chemistry) and CHM 402 (Advanced Inorganic Laboratory), CHM 441 (Chemistry of Biological Systems), and CHM 492 (Seminar in Chemistry) are replaced by CHM 391 (Forensic Science Seminar) and CHM 392 (Introduction to Criminalistics). This gives the student the full core curriculum in chemistry, most of the advanced courses, and a solid introduction into the field of chemical forensics.

The full curriculum for the BS degree in Chemistry and Forensic Chemistry is summarized on the attached spreadsheet.

Outcomes and Assessment

Chemistry laboratory experiences are one of the best ways to demonstrate student learning. In the laboratory students are expected to learn certain physical skills such as using equipment or making measurements. The student's success in this endeavor is easily demonstrated: the product was synthesized or the measured value was reasonable. Further, laboratory reports require the student to describe the success (or failure) of their physical skills and to integrate the results into the theoretical background provided in lecture courses. Thus, laboratory reports provide an ideal mechanism for assessing student outcomes, especially in the upper level laboratories.

To assess student outcomes for the different degree programs, final laboratory reports will be collected for each student from selected laboratory classes. The most complete assessment tool is the final report from the student's research experience because a research problem in chemistry is likely to require the student to integrate material from all of the areas of chemistry. However, to demonstrate progress, we will collect reports from disciplinary classes, as well. In most of the laboratory courses, the final "experiment" is a miniproject that integrates multiple skills from the rest of the course. Thus, these final laboratory reports reflect a significant portion of the material taught in the course. Students who take the seminar course (CHM 492) will also be required to turn in a copy of their presentation (typically, this means a Power Point file) as an additional assessment component. The entire set of material turned in by the student will be a portfolio of student progress and demonstrate that they have learned the skills necessary for the degree.

Only upper level courses will be used in construction of the student portfolio. This is partly for pedagogical reasons and partly for logistical reasons. The laboratory components of introductory chemistry (CHM 191 & CHM 192) and organic chemistry (CHM 226) heavily rely on introduction of basic skills that are repeated frequently throughout the rest of the curriculum. Further, since introductory chemistry and organic chemistry are service courses heavily enrolled by non-chemistry majors, the administrative burden is high with minimal useful feedback. Finally, since many students do not declare themselves as a chemistry major until after taking the introductory and organic courses, we can not even identify many majors until they start taking the upper level courses. The specific components of the portfolio for each degree will be:

<u>BS in Chemistry</u>: final lab reports from CHM 212, CHM 335, CHM 353, CHM 354, CHM 402, CHM 414, & CHM 425 and the CHM 492 presentation.

<u>BA in Chemistry</u>: final lab reports from CHM 212 & CHM 335.

<u>BS in Chemistry and Chemical Oceanography</u>: final lab reports from CHM 212, CHM 335, CHM 414, CHM 425, OCG 493, & OCG 494.

<u>BS in Chemistry and Forensic Chemistry</u>: final lab reports from CHM 212, CHM 335, CHM 414, CHM 425.

Each year the faculty will review the portfolios of the graduating seniors. The review will help the Chemistry Department identify areas of success and areas that need improvement in the curriculum. This review will rely on the judgment and expertise of the chemistry faculty and will change over time, depending upon the direction taken in the field of chemistry. Given the small size of the graduating class of chemistry majors (typically, 5 – 10 graduates per year), it is anticipated that it will take 5 to 10 years of annual data to establish baseline norms.

Rubrics:

Assessment of all reports will use the rubrics given in Table 1, below. The goal is to have all students meet or exceed expectations.

Table 1: Assessment Rubrics

Attribute	1 – Not Acceptable	2 – Below Expectations	3 – Meets Expectations	4 – Exceeds Expectations	Score
General Organization	Inappropriate content in most sections, tables and figures can not be read, spelling errors, grammar and punctuation errors, far too long or too short	Inappropriate content in some sections, some portions sloppy or difficult to read, few spelling errors, few punctuation or grammar errors	Appropriate content in all sections, all portions of report readable, no spelling, punctuation, or grammatical errors, appropriate length	Unique organization that enhances readability, unusually clear text, tables, or figures that improve understandability of the report	
Abstract – problem stated and conclusions summarized	No problem statement and no summary of conclusions	Problem stated with no conclusions or conclusions with no problem statement	Problem and key conclusions clearly stated	Problem statement and key conclusions stated elegantly	
Introduction – problem stated in context	No problem statement, no indication of context of problem, gives details of results	Problem stated poorly, limited discussion of context	Problem and context clearly stated	Problem and context elegantly stated	
Theoretical Background – in context with appropriate detail	None	Unclear or incomplete	Clear and complete	Elegant	
Results – experimental detail, methodology	No results	Incomplete results	Clearly stated	Elegantly stated	
Discussion – physical explanations of results in accord with background	None	Present but unclear or not connected to results and background	Clearly stated	Elegantly stated	
Conclusions	None or introduces ideas not developed in report	Weak, introduces ideas not in report, misses key ideas	Clearly stated, follow results and discussion in context	Elegantly stated	
References	Missing, incorrect format, not cited in report, unrelated to subject matter	Some cited, some inappropriate	Correct format, all cited in report, fit the context	Obscure but appropriate references cited	

Outcomes Assessment - Chemistry Department **Bachelor of Science Degree in Chemistry**

Total number of chemistry credits = 55 Total Number of Laboratory hours = 742

I = Introductory E = Emphasis R = Reinforcement A = Advanced	Freshman				Sophomore								Junior						Senior							
	CHM 191 Gen Chem I	CHM 192 Gen Chem II	MTH 141 Calculus I	MTH 142 Calculus II	CHM 212 Quant. Anal	CHM 226 Organic Lab	CHM 227 Organic I	CHM 228 Organic II	MTH 243 Multivar Calc	MTH 244 Differ Eq	PHY 203/273 Phys I w lab	PHY 204/274 Phys II w lab	CHM 335 P-Chem Lab	CHM 412 Instrumental	CHM 414 Instrum. Lab	CHM 431 P-Chem I	CHM 432 P-Chem II	PHY 205/275 Phys III w lab	CHM 353 Research	CHM 354 Research	CHM 401 Inorganic	CHM 402 Inorgan. Lab	CHM 425 Inter. Org. Lab	CHM 427 Intermed. Org.	CHM 441 Biological	CHM 492 Seminar
Required Areas Credit-hours	5	5	4	4	4	2	3	3	3	3	4	4	2	3	2	3	3	4	3	3	3	2	2	3	3	1
Analytical		I	Prerequisite and Ancillary Courses		E				Prerequisite and Ancillary Courses					E, A	E, A			Ancillary Courses	R	R						R
Solve problems for aqueous solutions & equilibria		I			E																					
Use statistics in chemistry applications					E									R												
Describe separations					I									E												
Interpret spectra		I			R	I		I						E										R		
Biochemistry																			R	R					E	R
Identify and understand the role of lipids								I																	I, E	
Identify and understand the role of carbohydrates								I																	I, E	
Identify and understand the role of proteins								I																	I, E	
Identify and understand the role of nucleic acids								I																	I, E	
Inorganic	I	I																	R	R	E, A	E, A				R
Categorize periodic properties	I																				E					
Distinguish bonding & structure	I																				E					
Explain main group chemistry	I																				E					
Explain transition metal chemistry																					E					
Organic	I					E	E	E											R	R			E, A	E, A		R
Specify functional groups							E																			
Summarize structure & reactivity	I						E																	E, R		
Describe and create reaction mechanisms							I	E																E, R		
Outline organic syntheses							I	E																E, R		
Physical	I	I											E			E	E		R	R						R
Solve problems in thermodynamics	I	I														E										
Solve problems in quantum mechanics	I																E									
Solve problems in kinetics		I															E									
Laboratory hours	42	42			42	84							56		84				126	126		56	84			
Keep legible & complete experimental records	I	I				R							E		E				R	R		R	R			
Synthesize organic compounds						E													R	R			E			
Synthesize inorganic compounds																			R	R		E				
Perform accurate & precise measurements	I	I											E		E				R	R		E	E			
Use modern instrumentation		I				E							E		E				R	R		E	E			
Interpret experimental results	I	I				E							E		E				R	R		E	E			
Analyze data statistically													E		E				R	R						
Anticipate & recognize chemical hazards	I	I				E							R		R				R	R		E	E			
Design experiments															E				E	E		E				
Plan & execute experiments using literature															E				E	E		E				
Communicate using oral & written reports	I	I				E							E		E				E	E		E				
Work in small teams	I	I				E							E		E				E	E						

Outcomes Assessment - Chemistry Department **Bachelor of Arts Degree in Chemistry**

Total number of chemistry credits = 33 Total Number of Laboratory hours = 266

I = Introductory E = Emphasis R = Reinforcement A = Advanced	Freshman				Sophomore						Junior			Senior **Select One Elective**			
	CHM 191 Gen Chem I	CHM 192 Gen Chem II	MTH 141 Calculus I	MTH 142 Calculus II	CHM 212 Quant. Anal	CHM 226 Organic Lab	CHM 227 Organic I	CHM 228 Organic II	PHY 203/273 Phys I w lab	PHY 204/274 Phys II w lab	CHM 335 P-Chem Lab	CHM 431 P-Chem I	CHM 432 P-Chem II	CHM 401 Inorganic	CHM 412 Analytical	CHM 427 Intermed. Org.	CHM 441 Biological
Topic Areas Credit-hours	5	5	4	4	4	2	3	3	4	4	2	3	3	3	3	3	3
Analytical		I	Prerequisite and Ancillary Courses		E				Prerequisite and Ancillary Courses						E, A		
Solve problems for aqueous solutions & equilibria		I			E												
Use statistics in chemistry applications					E										R		
Describe separations					I										E		
Interpret spectra		I			R	I		I							E	R	
Biochemistry																	E
Identify and understand the role of lipids								I									I, E
Identify and understand the role of carbohydrates								I									I, E
Identify and understand the role of proteins								I									I, E
Identify and understand the role of nucleic acids								I									I, E
Inorganic	I	I												E,A			
Categorize periodic properties	I													E			
Distinguish bonding & structure	I													E			
Explain main group chemistry	I													E			
Explain transition metal chemistry														E			
Organic	I					E	E	E								E, A	
Specify functional groups							E										
Summarize structure & reactivity	I						E									E, R	
Describe and create reaction mechanisms							I	E								E, R	
Outline organic syntheses							I	E								E, R	
Physical	I	I									E	E	E				
Solve problems in thermodynamics	I	I										E					
Solve problems in quantum mechanics	I												E				
Solve problems in kinetics		I											E				
Laboratory hours	42	42			42	84					56						
Keep legible & complete experimental records	I	I				R					E						
Synthesize organic compounds						E											
Synthesize inorganic compounds																	
Perform accurate & precise measurements	I	I									E						
Use modern instrumentation		I				E					E						
Interpret experimental results	I	I				E					E						
Analyze data statistically											E						
Anticipate & recognize chemical hazards	I	I				E					R						
Design experiments																	
Plan & execute experiments using literature																	
Communicate using oral & written reports	I	I				E					E						
Work in small teams	I	I				E					E						

Outcomes Assessment - Chemistry Department **Bachelor of Science Degree in Chemistry & Chemical Oceanography**

Total number of chemistry credits = 55 Total Number of Laboratory hours = 686

I = Introductory E = Emphasis
R = Reinforcement A = Advanced

	Freshman				Sophomore								Junior						Senior						
	CHM 191 Gen Chem I	CHM 192 Gen Chem II	MTH 141 Calculus I	MTH 142 Calculus II	CHM 212 Quant. Anal	CHM 226 Organic Lab	CHM 227 Organic I	CHM 228 Organic II	MTH 243 Multivar Calc	MTH 244 Differ Eq	PHY 203/273 Phys I w lab	PHY 204/274 Phys II w lab	CHM 335 P-Chem Lab	CHM 431 P-Chem I	CHM 432 P-Chem II	OCG 451 Ocean Sci	OCG 494 Ind Study	PHY 205/275 Phys III w lab	CHM 401 Inorganic	CHM 425 Inter. Org. Lab	CHM 427 Intermed. Org.	CHM 412 Instrumental	CHM 414 Instrum. Lab	OCG 493 Ind Study	OCG 521 Chem Ocean
Topic Areas Credit-hours	5	5	4	4	4	2	3	3	3	3	4	4	2	3	3	3	3	4	3	2	3	3	2	3	3
Analytical		I	Prerequisite and Ancillary Courses		E				Prerequisite and Ancillary Courses									Ancillary Courses				E, A	E, A		
Solve problems for aqueous solutions & equilibria		I			E																				
Use statistics in chemistry applications					E																	R			
Describe separations					I																	E			
Interpret spectra		I			R	I		I													R	E			
Chemical Oceanography																E	E							E	E
Inorganic	I	I																	E, A						
Categorize periodic properties	I																		E						
Distinguish bonding & structure	I																		E						
Explain main group chemistry	I																		E						
Explain transition metal chemistry																			E						
Organic	I					E	E	E												E, A	E, A				
Specify functional groups							E																		
Summarize structure & reactivity	I						E														E, R				
Describe and create reaction mechanisms							I	E													E, R				
Outline organic syntheses							I	E													E, R				
Physical	I	I											E	E	E										
Solve problems in thermodynamics	I	I												E											
Solve problems in quantum mechanics	I														E										
Solve problems in kinetics		I													E										
Laboratory hours	42	42			42	84							56				126			84			84	126	
Keep legible & complete experimental records	I	I				R							E				R			R			E	R	
Synthesize organic compounds						E														E					
Synthesize inorganic compounds																									
Perform accurate & precise measurements	I	I											E				R			E			E	R	
Use modern instrumentation		I				E							E				R			E			E	R	
Interpret experimental results	I	I				E							E				R			E			E	R	
Analyze data statistically													E				R						E	R	
Anticipate & recognize chemical hazards	I	I				E							R							E			R		
Design experiments																	E						E	E	
Plan & execute experiments using literature																	E						E	E	
Communicate using oral & written reports	I	I				E							E				E						E	E	
Work in small teams	I	I				E							E				E						E	E	

Outcomes Assessment - Chemistry Department

Total number of chemistry credits = 55

Bachelor of Science Degree in Chemistry & Forensic Chemistry

Total Number of Laboratory hours = 686

I = Introductory E = Emphasis
R = Reinforcement A = Advanced

Topic Areas	Freshman				Sophomore							
	CHM 191 Gen Chem I	CHM 192 Gen Chem II	MTH 141 Calculus I	MTH 142 Calculus II	CHM 212 Quant. Anal	CHM 226 Organic Lab	CHM 227 Organic I	CHM 228 Organic II	MTH 243 Multivar Calc	MTH 244 Differ Eq	PHY 203/273 Phys I w lab	PHY 204/274 Phys II w lab
Credit-hours	5	5	4	4	4	2	3	3	3	3	4	4
Analytical		I	Prerequisite and Ancillary Courses		E				Prerequisite and Ancillary Courses			
Solve problems for aqueous solutions & equilibria		I			E							
Use statistics in chemistry applications					E							
Describe separations					I							
Interpret spectra		I			R	I		I				
Forensic Science												
Inorganic	I	I										
Categorize periodic properties	I											
Distinguish bonding & structure	I											
Explain main group chemistry	I											
Explain transition metal chemistry												
Organic	I					E	E	E				
Specify functional groups							E					
Summarize structure & reactivity	I						E					
Describe and create reaction mechanisms							I	E				
Outline organic syntheses							I	E				
Physical	I	I										
Solve problems in thermodynamics	I	I										
Solve problems in quantum mechanics	I											
Solve problems in kinetics		I										
Laboratory hours	42	42			42	84						
Keep legible & complete experimental records	I	I				R						
Synthesize organic compounds						E						
Synthesize inorganic compounds												
Perform accurate & precise measurements	I	I										
Use modern instrumentation		I				E						
Interpret experimental results	I	I				E						
Analyze data statistically												
Anticipate & recognize chemical hazards	I	I				E						
Design experiments												
Plan & execute experiments using literature												
Communicate using oral & written reports	I	I				E						
Work in small teams	I	I				E						

Topic Areas	Junior							Senior						
	CHM 335 P-Chem Lab	CHM 431 P-Chem I	CHM 432 P-Chem II	CHM 391	CHM 392	CHM 354 Ind Study	PHY 205/275 Phys III w lab	CHM 401 Inorganic	CHM 425 Inter. Org. Lab	CHM 427 Intermed. Org.	CHM 412 Instrumental	CHM 414 Instrum. Lab	CHM 354 Ind Study	CHM 391
Credit-hours	2	3	3	1	3	3	4	3	2	3	3	2	3	2
Analytical							Ancillary Courses				E, A	E, A		
Solve problems for aqueous solutions & equilibria														
Use statistics in chemistry applications											R			
Describe separations											E			
Interpret spectra										R	E			
Forensic Science				E	E	E							E	E
Inorganic								E, A						
Categorize periodic properties								E						
Distinguish bonding & structure								E						
Explain main group chemistry								E						
Explain transition metal chemistry								E						
Organic									E, A	E, A				
Specify functional groups														
Summarize structure & reactivity										E, R				
Describe and create reaction mechanisms										E, R				
Outline organic syntheses										E, R				
Physical	E	E	E											
Solve problems in thermodynamics		E												
Solve problems in quantum mechanics			E											
Solve problems in kinetics			E											
Laboratory hours	56					126			84			84	126	
Keep legible & complete experimental records	E					R			R			E	R	
Synthesize organic compounds									E					
Synthesize inorganic compounds														
Perform accurate & precise measurements	E					R			E			E	R	
Use modern instrumentation	E					R			E			E	R	
Interpret experimental results	E					R			E			E	R	
Analyze data statistically	E					R						E	R	
Anticipate & recognize chemical hazards	R								E			R		
Design experiments						E						E	E	
Plan & execute experiments using literature						E						E	E	
Communicate using oral & written reports	E					E						E	E	
Work in small teams	E					E						E	E	