UNIVERSIDAD DE COSTA RICA

SISTEMA DE ESTUDIOS DE POSGRADO

CHEMMING WORDS: ENGLISH FOR CHEMISTRY STUDENTS

Trabajo final de investigación aplicada sometido a la consideración de la Comisión del Programa de Estudios de Posgrado en Enseñanza del Inglés como Lengua Extranjera para optar al grado y título de Maestría Profesional en Enseñanza del Inglés como Lengua Extranjera.

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"Este trabajo final de investigación aplicada fue aceptado por la Comisión del Programa de Estudios de Posgrado en Enseñanza del Inglés como Lengua Extranjera de la Universidad de Costa Rica, como requisito parcial para optar al grado y título de Maestría Profesional en Enseñanza del Inglés como Lengua Extranjera."

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Resumen

Este proyecto de investigación intenta identificar los mayores problemas de pronunciación en inglés que tienen un grupo de estudiantes de química de la Universidad de Costa Rica. Además, la pronunciación de la letra "o" en inglés fue destacada. Esta investigación fue conducida en un curso de inglés para propósitos específicos. Cada participante grabó 80 palabras relacionadas con química. El análisis de la información mostró que el cambio en las vocales, el acento en las palabras, el cambio en los diptongos, el cambio en consonantes, y la inserción o eliminación de sonidos son los principales problemas de pronunciación. Esta investigación encontró seis substituciones de los sonidos correctos de la letra "o" en inglés; las tres mayores substituciones son /o/ en lugar de /ɑ/, /o/ en lugar de /oʊ/ y /ə/ en lugar de /ɑ/. Para ayudar a solucionar los problemas encontrados, se dan sugerencias que están relacionadas con la enseñanza del acento de las palabras en inglés, diferentes pronunciaciones de la letra "o" en inglés, diptongos en inglés así como la regla de la letra "e" al final de las palabras, la cual es muda en muchas ocasiones en inglés.

Palabras clave: problemas de pronunciación, pronunciación de la letra "o"

Abstract

This research project attempts to identify the mayor pronunciation problems that a group of chemistry students from the University of Costa Rica have. Moreover, the pronunciation of the letter "o" was highlighted. This investigation was conducted in an English for Specific Purpose (ESP) course. Each participant recorded 80 chemistry-related words. The data analysis showed that vowel change, wrong stress, diphthong change, consonant change, and insertion or deletion of sounds are the major pronunciation problems. This study found six substitutions of the correct realization of the letter "o"; the three major ones are /o/ instead of /ɑ/, /o/ instead of /oʊ/, and /ə/ instead of /ɑ/. In order to overcome the problems found, a list of suggestions are provided concerning ways to teach word stress, different pronunciations of the letter "o", diphthongs, and the final-silent-letter-e rule.

Keywords: pronunciation problems, pronunciation of the letter "o"

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ACS: American Chemistry Society

ACTFL: American Council on the Teaching of Foreign Languages

EAP: English for Academic Purposes

EOP: English for Occupational Purposes

ESP: English for Specific Purposes

TEFL: Teaching English as a Foreign Language

UCR: University of Costa Rica

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The Master's Program in Teaching English as a Foreign Language (TEFL) at the University of Costa Rica (UCR) uses English for Specific Purposes (ESP) as the platform for preparing future professionals in English teaching. Consequently, this master's program demands its students to engage with a professional population interested in learning English to succeed at work and/or for academic purposes. Therefore, the Master's Program in TEFL proposed an ESP course for a group of chemistry students at the UCR. Hence, both the chemistry students and the Master's Program in TEFL will benefit; chemistry students will learn English, which is necessary in their major and professional lives, and the English teaching students will conduct their practicum. Consequently, the needs analysis of the target population, the design of the ESP course, and the teaching of this course are the three major parts of the professional practicum for the TEFL students.

The target population is a group of chemistry students who are in different levels of the academic major. In terms of language, students are required to read articles and books that are published in English. Therefore, this population needs English as a tool to access leading written information to work in their laboratories. Sometimes, they are tested based on an assigned reading. Moreover, this population needs to attend conferences at their school where international chemists are invited, and English is their means of communication. As future chemists, this population will be required to use English to enroll in a master's program overseas as well as to explain their findings, improvements, and inventions to their respective stakeholders. Also, as English speakers, the future chemists will have to describe chemical processes, communicate among colleagues and work teams, explain changes in formulas, ask questions about chemical features, and explain characteristics of matter, as well as ask questions and give instructions.

Matching the students' language needs with Brown's (2001) micro-skills, chemistry students, as English readers, have to process written texts at an efficient rate of speed to suit the purpose, recognize grammatical word classes, systems, patterns, and rules, and recognize the communicative function of written text. As English listeners, the student population has to retain chunks of language in short-term memory, discriminate between the distinctive sounds of English, and develop means of retaining information (note taking at conferences). As English speakers, the future chemists will have to produce chunks of language of different lengths, produce English stress patterns, and use an adequate number of words to accomplish a given purpose. Hence, an ESP course for chemists had to be focused on reading, listening, and speaking as dominant macro-skills pertinent to current and future needs.

CHAPTER I

Needs Analysis

A. Procedures

To conduct the needs analysis, the chemistry students were contacted in order to collect data; formal and informal instruments were used. Firstly, an electronic mail was sent to the target population to start gathering general information; these data facilitated the design of a questionnaire that the target population completed by e-mail. Additionally, two other sources of information were used. One was the contact person, and the other one was an interview with an advanced chemistry student. The contact person was reached with questions which were sent by electronic mail; this contact person is a member of the Chemistry Student Association. The advanced student helped to deepen the understanding of the chemistry students' tasks and needs for English in their academic life and future career. This personal interview started with the same five questions that were sent to the population, and continued with spontaneous questions that came up to clarify key elements of a chemist's chores. Additionally, some videos regarding chemistry were viewed in order to understand the scientific field of the ESP population.

B. Instruments

The first instrument was a set of five questions regarding common tasks that chemists carry out, possible workplaces, the need for English for academic purposes, the use of English in their professional future, and recommendations of chemistry materials in English (see Appendix A). The second instrument was a questionnaire for the contact

person with six questions which were sent by electronic mail (see Appendix B); this instrument was intended to get information from the person in charge of the ESP population.

A questionnaire (see Appendix C) was designed to collect data as a primary instrument to analyze the target population. This questionnaire has questions that Dörnyei (2007) categorizes as being of either factual or behavioral nature. For this author, factual questions are used to find out about the respondents while behavioral questions focus on finding out actions and habits the respondents are doing or have done in the past. This author also has stated that mixed methods approach is an effective way to gather data, as it encompasses both qualitative and quantitative analysis.

The questionnaire was in Spanish and organized in four sections, which took less than five minutes to complete.

The first section aims to obtain personal information. Five questions were asked regarding age range, major level, English acquisition, and possible proficiency level. Other personal data were given to the researchers when the population was assigned. The second section gathers information about the use of English at the university. Three questions deal with the use of English and the frequency of this use. Also, 12 academic tasks were listed for the participants to select the ones that they need to perform by using the language. The third section aims the future need of English. A list of tasks was presented for the participants to select future tasks that may require English to be performed. The last section focuses on the students' preferences. This section has five questions regarding activities in the future ESP course, perceived level of difficulty in each macro-skill, priorities of the future course, as well as the possible schedule of the classes. The

questionnaire consists of 15 questions in total, and was administered via electronic mail, which was a simple means for the participants to access and complete.

C. General Description of the Institution

The UCR´s School of Chemistry (2018, p.1) has a program that was conceived from a multidisciplinary perspective. This program contains humanities, biology, physics, and mathematics courses, as well as a fundamental core of chemistry specialties. To obtain the bachelor's degree, students have to complete eight university terms and 300 hours of community outreach. To obtain the Licenciatura degree, two more university cycles are necessary. The chemistry program does not have any English courses; therefore, students have to deal with their linguistic needs in English in their own way.

D. General Description of the Field of Work

The field of study of the target population is chemistry. The American Chemistry Society (ACS) claims that a chemistry practitioner "benefit[s] the Earth and its people" and "improve[s] people's lives through the transforming power of chemistry" (2018). According to Bagley (2017), chemistry "is the study of matter, its properties, how and why substances combine or separate to form other substances, and how substances interact with energy (p. 1)." Moreover, Bagley (2017) states that chemistry has five main branches of study, which are the following:

1- Analytical chemistry uses qualitative and quantitative observation to identify and measure the physical and chemical properties of substances.

2- Physical chemistry combines chemistry with physics. Physical chemists study how matter and energy interact. Thermodynamics and quantum mechanics are two of the important branches of physical chemistry.

3- Organic chemistry specifically studies compounds that contain the element carbon (all of the molecules that make up living tissue have carbon as part of their makeup).

4- Inorganic chemistry studies materials such as metals and gases that do not have carbon as part of their makeup.

5- Biochemistry is the study of chemical processes that occur within living organisms. (p.1)

Furthermore, Bagley (2017, p.1) claims that chemists improve many products, from the food we eat and the clothing we wear, to the materials with which we build our homes. Chemistry helps to protect our environment, and searches for new sources of energy.

In this same regard, the chemistry students stated that some tasks that chemists have to do are related to analysis of chemicals, production of chemicals, identification of new chemicals, investigation and development of new chemicals, quality control, determination of physics/chemical parameters, and establishment of procedures for chemical-product quality control. These tasks can be carried out in two different work places: industry or the academic field. Regarding industry, a chemist can work in the food industry, materials industry, medicine, pharmacy, microbiology, agriculture, geology, and different companies; in the academic field, a chemist can teach and do research.

E. Interests of the Primary Stakeholders

The chemistry program at the UCR requires its students to be able to manage English to cope with academic tasks that use this language as a means for obtaining information concerning the field. Hence, the stakeholder's main interest is to assist the students with tools to read research papers and chapters of books. Additionally, the School of Chemistry invites English speakers to give conferences at the university; consequently, students are required to go to these speeches and grasp information from an oral stream. Going to a conference demands particular listening skills. Likewise, the chemistry program forms professionals that need to be competent in their future careers. Thus, this program agrees with the development of speaking skills for the students to succeed as future chemists since updating, studies abroad, and globalization of the information are some demands that this population will face.

F. Group Profile

1. Educational Background

The design of the diagnostic test for chemistry students at the UCR was based on the needs and preferences of this population. The needs of this population can be divided into two parts: present needs and future needs. This population is currently taking courses towards completing their major, and they require English to succeed in academic tasks pertaining to their studies. As future chemists, this population will need English as a tool to develop as competitive professionals in their field. In other words, ESP for this population presents a mixture of English for Academic Purposes (EAP) and English for Occupational

Purposes (EOP). Therefore, to grasp the rationale of the diagnostic test is necessary to understand what those needs are.

2. Description of the Needs

Regarding EAP, the most conspicuous need that chemistry students have is understanding, extracting, and using information from written texts. Chemistry students are required to read research papers and chapters from books which are in English. These students have to be able to recognize general ideas as well as specific information. They also have to go through descriptions and chemical processes. The aforementioned necessities convey the mastery of specific and specialized chemistry vocabulary. According to this population, updated current information is published in English; consequently, reading comprehension is fundamental for chemistry students.

Another EAP need for this population is understanding, extracting, and using information from oral texts. Chemistry students are required to attend conferences held often in their department. English-speaking foreign chemists are invited to present lectures to the target population. Consequently, this academic stage presents new challenges for chemistry students since they have to understand the discourse markers and moves of an academic presentation, as well as recognize general ideas, specific information, differentiate facts, opinions, and results. Furthermore, asking questions is important to interact with the presenter. Technical chemistry word knowledge is crucial to develop these listening micro-skills. Developing listening strategies is important for this ESP population. As an additional EAP possibility, this population has the chance to go abroad to pursue an advanced degree. This possible future scenario brings up another need: oral

communication. The oral skills in this context are shared with the ones in EOP described below. Therefore, developing oral skills is a future need that this population will have.

On the other hand, EOP needs are present in this population. Once they finish their major, the target population will join the work force. Being able to communicate orally with colleagues or stakeholders is necessary to be efficient and competent. Regarding speaking production, this population has to be able to describe chemical processes, reporting findings, explaining reasons as well as asking questions. Hence, correct pronunciation of vocabulary related to the target field is essential. Appropriate intonation of questions and statements is necessary to be understood by the scientific community. To sum up, speaking skills are a future EOP need that this population must fulfill.

3. Description of the Wants

The target population has particular wishes that the ESP course will try to please. The chemistry students want to be able to hold a conversation in English about chemistry issues. This population would also like to view and understand videos about chemistry as a source of information regarding their field. Another wish that this population expressed is the possibility to explain chemical processes correctly; this is comprehensible since one of the main tasks as chemistry students and future chemists is the description of chemical processes. Likewise, to be able to orally explain reasons to modify or improve a chemical formula is part of the expectations of the target population.

4. Description of the Lacks

The most salient lack of this population is related to oral communication. This population stated that they lack speaking skills to express themselves correctly and with

confidence, which represents an obstacle to speaking. According to the population, the mastery of chemistry vocabulary and its correct pronunciation are the two major problems to solve; both vocabulary of the field and the correct pronunciation limit them from achieving effective oral communication.

G. Diagnostic Test

The diagnostic test uses the American Council on the Teaching of Foreign Languages (ACTFL) as a framework. This test includes three sections on reading, listening, and speaking; each of these sections has three proficiency levels: novice, intermediate, and advanced (see Appendix D). In addition, the test targets the first level of advanced proficiency, which ACTFL refers to as *advanced low.* Since the listening section involves three-time playing recordings, the population started and finished the planned tasks at the same time. Later, each participant worked on the reading section in the allotted time to take the test. Finally, the participants will go through the oral tasks planned for this purpose. This arrangement maximized the time that the population spent taking the test. Furthermore, the listening section is worth 25 points, the reading is worth 30 points, and the speaking section is 30 points. In total, the diagnostic test for chemistry students is 85 points. This number of points was considered enough to ensure reliability because it is high enough, as Brown (2004) suggests. Participants will have 90 minutes to take the test. The speaking section is estimated to last 15 minutes for each speaker. Based on the needs analysis, writing was not included as part of the diagnostic test because the target population does not need to perform any writing tasks.

1. General Administration Information

The administration of the test took place in San José downtown at a language school where one of us works. This place was ideal since it has the necessary facilities to administer a test, such as technological devices, furnishings, and appropriate rooms. Moreover, four schedules were offered to the participants for their convenience; the schedules were Friday from 4:00 pm to 5:30 pm, Saturday from 3:30 pm to 5:00, Monday and Wednesday from 10:30 am to 12:00 pm.

2. Macro and Micro Listening Skills

Listening is the first macro-skill tested. This section addresses the listening needs that the chemistry students have in their academic activities when they attend conferences at their department. Each part of the listening section has two tasks which aim to obtain reliable information about the proficiency level under evaluation. With the set of six tasks, the listening section also provides validity because the researchers can draw inferences and jump into conclusions based on the results obtained from this part.

This section has three parts; each part addresses novice, intermediate, and advanced proficiency levels. Each proficiency level uses different audios with topics that are based on students' reported interests. The rate of delivery is also incremental, matching the proficiency requirements. For the novice part, a 2:24 minute-long audio named Simple Chemistry Magic Trick was chosen because the audio is about the rate of chemical reactions. The audio includes colors, chemistry laboratory equipment vocabulary, and descriptions of changes. The simplicity of the audio makes it ideal to test novice listeners.

Moreover, the topic of the audio was selected according to the interests of the students because the audio is about chemical kinetics.

According to the ACTFL (2012), novice listeners can:

> understand key words, true aural cognates, and formulaic expressions that are highly contextualized and highly predictable. They understand words and phrases from simple questions, statements, and high-frequency commands. They can recognize speech that they can anticipate. In this way, these listeners tend to recognize rather than truly comprehend.

Therefore, two tasks were designed based on the selected audio; for the first one, test-takers work with a productive response item by identifying three key words to complete two sentences about the video.

The listeners also have to identify the color change in some substances by matching the initial color to the last one. This task tests the capacity to retain chunks of language as well as the development of means of retaining information (Brown, 2007); thus, this item is receptive. These tasks intend to test the listeners' skill to identify words of the chemistry field as well as their skill to identify changes in substances. This block of items tends to test the participants' capacity to recognize words of their field as well as recognize color changes in substances since they are part of the physical properties of matter.

At the intermediate level, ACTFL states that:

> listeners can understand information conveyed in simple, sentence-length speech on familiar topics. They can understand speech that conveys basic information. This speech is simple, minimally connected, and contains high-

> frequency vocabulary; moreover, they are able to comprehend meaning from simple, straightforward speech.

Consequently, from a 2:31 minute-long audio called "Importance of pH in Everyday Life", a set of information questions is presented to test participants' ability to extract information from the speech stream. The answers are provided in sentence-like structures as well as phrases. Furthermore, a fill-in-the-blank task is provided to test comprehension of meaning conveyed in short sentences with specific vocabulary related to the field. This way, participants are required to demonstrate their ability to deal with phrases and sentence-like utterances, along with technical jargon. Both items require productive responses. This block of items aims to test the participants' ability to recognize specific information such as numbers and vocabulary used within the field.

Related to this, ACTFL claims that:

> advanced listeners can understand the main ideas and most supporting details in connected discourse. They can also derive some meaning from oral texts at higher levels if they possess significant familiarity with the topic or context. They can understand speech that is authentic and connected. This speech is lexically and structurally uncomplicated. The discourse is straightforward and is generally organized in a clear and predictable way. They have sufficient knowledge of language structure to understand basic time-frame references.

Based on the previous description, the diagnostic test presents two productive tasks, which are answering questions and note taking. These two tasks intend to test the listeners'

ability to comprehend specific and general data inserted in 1:51 minute-long audio titled "What are Polymers?" Three questions were asked to test participants' capacity to recognize and retain chunks of language. Similarly, the note-taking item asks for a list of three characteristics; therefore, the participants have to recognize, retain, and write them simultaneously. This item requires advanced listening skills.

In summary, the listening section intended to test the micro-skills of recognizing general ideas, specific information, and technical chemistry word knowledge imbedded in speech form. The utterance speed is incremental, meaning that the first audio had a slower pace intended for novice-level proficiency, while the second audio had a faster pace intended for intermediate-level proficiency. Each audio was played three times for the participants to complete the tasks.

3. Macro and Micro Reading Skills

Reading is the second macro-skill to be tested. Each part of the reading section has three tasks which aim to obtain reliable information about the proficiency level under evaluation. With the set of nine assessment tasks, the reading section aims to establish reliability. The texts to test the participants were chosen according to the topics suggested in the needs analysis; hence, the texts are meaningful for the population. The texts are about chemicals, laboratory equipment, and two sections of a research paper. This section has three parts; each part addresses novice, intermediate, and advanced proficiency level. According to ACTFL, novice readers can:

> understand key words and cognates, as well as formulaic phrases that are highly contextualized. They are able to get a limited amount of information

> from highly predictable texts in which the topic or context is very familiar. These readers may rely heavily on their own background knowledge and extralinguistic support (such as the imagery on the weather map or the format of a credit card bill) to derive meaning. At the Novice level, recognition of key words, cognates, and formulaic phrases makes comprehension possible.

Therefore, the first part of the reading section has three tasks addressing the novice reader; the first item is receptive, and the other two are productive. From a chart about chemicals and their characteristics, the participants have to process written information to complete a matching exercise, a fill-in-the-blank section, and short-answer tasks. This part aims to test the participants' capacity to recognize chemistry-related words, recognize grammatical word classes, and find specific information.

At the intermediate level, ACTFL states that:

> readers can understand information conveyed in simple, predictable, loosely connected texts. Readers rely heavily on contextual clues. They can most easily understand information if the format of the text is familiar. These texts are non-complex and have a predictable pattern of presentation. The discourse is minimally connected and primarily organized in individual sentences and strings of sentences containing predominantly high-frequency vocabulary. Intermediate-level readers are most accurate when getting meaning from simple, straightforward texts.

Thus, the second part of the reading section presents a text about chemical equipment and functions. This text complies with the characteristics of "simple, predictable, minimally connected, primarily organized in individual sentences and strings of sentences," which make it ideal to test intermediate readers. With this text, participants have to identify laboratory chemical tools and their functions. Furthermore, they have to extract characteristics of a volumetric flask, and they have also to answer comprehension questions. This part has the intention of testing the capacity to find specific information, associate an object with its description, and identify characteristics.

Similarly, ACTFL claims that:

> advanced readers can understand the main idea and supporting details of authentic narrative and descriptive texts. Readers are able to compensate for limitations in their lexical and structural knowledge by using contextual clues. Comprehension is likewise supported by knowledge of the conventions of the language (e.g., noun/adjective agreement, verb placement, etc.). When familiar with the subject matter, Advanced-level readers are also able to derive some meaning from straightforward argumentative texts (e.g., recognizing the main argument). Advanced-level readers are able to understand texts that have a clear and predictable structure. Advanced-level readers demonstrate an independence in their ability to read subject matter that is new to them. They have sufficient control of standard linguistic conventions to understand sequencing, time frames and chronology.

Based on the previous traits, the third reading part presents the Introduction and Conclusions sections of a research paper called "Applications of the Sol–Gel Process Using Well-Tested Recipes". These sections match the characteristics of "authentic narrative and descriptive texts, and clear and predictable structure" described above. With these two sections, test-takers have to infer information from the text by answering questions. This task requires productive response skills. Moreover, a receptive response item is presented to promote inferencing through a multiple-choice item. Furthermore, chemistry students have to extract specific information to complete two graphic organizers. Consequently, the identification of general ideas as well as specific information is at stake, as they were stated in the needs that chemistry students have when they have to cope with reading for academic purposes.

4. Macro and Micro Speaking Skills

Speaking is the last macro-skill to be tested. The speaking section matched the needs that the target population will have in their professional future. Each part of the speaking section has at least two tasks which aim to obtain reliable information about the proficiency level under evaluation. With the set of seven tasks, the speaking section aims to establish test reliability and validity. Through these seven tasks, the test intends to obtain information regarding the speaking micro-skills addressed. This section has three parts; each part respectively addresses novice, intermediate, and advanced proficiency level. The speaking section has a warm-up part for the purpose of relaxing and preparing the participants for the speaking tasks. This warm-up consists of five personal questions that the participants will answer, but they will not be part of the testing (Coombe, Folse, & Hubley, 2007).

According to ACTFL, novice speakers can:

> communicate short messages on highly predictable, everyday topics that affect them directly. They do so primarily through the use of isolated words and phrases that have been encountered, memorized, and recalled. Novice-level speakers may be difficult to understand even by the most sympathetic interlocutors accustomed to non-native speech.

Hence, to address novice-level speakers, the participants were asked to pretend to be employed in a laboratory that is new but empty. With the help of a card, they were required to name six tools that they need in the laboratory. They also had to choose two of those tools, and state what they are for and what they look like. The tasks look for the production of minimal utterances and basic descriptions of chemistry tools by uttering chunks of language of different lengths.

At the intermediate level, ACTFL states that

> Speakers are able to recombine learned material in order to express personal meaning. Intermediate-level speakers can ask simple questions and can handle a straightforward survival situation. They produce sentence-level language, ranging, typically in present time. Intermediate-level speakers are understood by interlocutors who are accustomed to dealing with non-native learners of the language.

Following the hypothetical situation of working in a laboratory, the participants were required to state three safety guidelines necessary in a chemistry laboratory. Similarly, they were asked about three common workplace accidents that happen in those

places. With these tasks, test-takers have the opportunity to produce utterances that range "from discrete sentences to strings of sentences." Moreover, the participants had to ask two questions about the imaginary situation of creating a new product for cleaning, a task that a chemist may be asked to do. This way, the target population's need for asking questions will be tested.

ACTFL states that:

> Speakers at the Advanced level engage in conversation in a clearly participatory manner in order to communicate information. The topics are handled concretely by means of narration and description in the major time frames of past, present, and future. The language of Advanced-level speakers is abundant, the oral paragraph being the measure of Advanced-level length and discourse. Advanced-level speakers have sufficient control of basic structures and generic vocabulary to be understood by native speakers of the language, including those unaccustomed to non-native speech.

The diagnostic test presented two hypothetical situations which took into consideration the aforementioned characteristics. In the first situation, students pretended to be presenters at a conference. With the assistance of a note card, they will explain the water molecule and the difference between glucose and fructose on the chemical level. In both situations, participants received a card with prompts to guide their speech as well as pictures of the water molecule and the chemical structure of the glucose and fructose. These two topics were appropriate because the chemistry students are familiar with the graphic representation of molecules; what was at stake was their capacity to orally express

main ideas, details, and descriptions; provide examples and produce chunks of language of different lengths; and use grammatical rules and patterns, as well as the use of vocabulary regarding the field of chemistry. Consequently, with these two productive tasks, chemistry students were able "to communicate information." They also had the opportunity to demonstrate "sufficient control of basic structures and generic vocabulary to be understood."

After these three parts of the speaking section, test administrators winded the participants down by thanking them for their time spent taking the diagnostic test as well as by encouraging them to continue their chemistry studies and by motivating them to study English as a tool to perform better as future chemists. Test administrators also asked the participants if they had any questions regarding the diagnostic test, or about the process they are involved in (Omaggio, 2001).

5. General Description of Framework

ACTFL proficiency guidelines have been the object of criticism; however, several authors agree on the positive aspects of these guidelines. For instance, Hall (2007) agrees that ACTFL guidelines "may be useful for their descriptive power and arguably realistic assumptions of language development (p. 1)." Moreover, Sun (2007) consider that these guidelines "have been formulated based on a functional approach to language, which views language as a channel to express functional meaning (p. 1)." In the same way, Donbeck (2007) states that ACTFL guidelines "are fairly comprehensive in that they do address the multiple skills and uses for language (p. 1)." Moreover, this same author notes that they "serve as a sort of sequencing chart, mapping out the abilities and potential shortcomings of an archetypal learner at each stage (p. 1)." Wiese (2007) advocates ACTFL guidelines by stating that "many very discrete examples of what learners can do at each stage are given

(p. 1)." By putting together all these comments, it seems that ACTFL Proficiency Guidelines are a respectable framework to structure a proficiency test, even though "placement testing is subjective" (Wiese, 2007, p. 1).

6. Description of the Rubrics

In order to assess the speaking skills of the participants, an analytical rubric was designed. This rubric consisted of six criteria, and ranged in scale from 1 point to 5 points (see Appendix E). Dudley Evans and St John (1998) has stated that "ESP courses are like to look at: structuring, visuals, voice, and advance signaling as well as language" (p.122) regarding oral presentations. On the other hand, speaking consists of three linguistic characteristics; they are phonological, lexico-grammatical, and discourse features (Bygate, 2009). Consequently, the criteria assessed in the rubric are task completion, content, vocabulary, pronunciation, accuracy, and fluency. All of these aspects were considered important to the test administrators in order to fully assess the speaking skills of the participants. Furthermore, the criteria mentioned was also deemed important to the participants, as was outlined in the needs analysis. The participants expressed an interest in improving their pronunciation, vocabulary, and ability to communicate fluently. As a result, the aforementioned components were included in the rubric along the range of 1 for a poor performance to 5 for an excellent performance. Students were evaluated on their capacity to perform in each area based on the descriptors. For instance, in order to obtain a *5-excellent* in Content, the participant is required to provide rich and detailed explanations along with examples in order to demonstrate comprehension. The descriptors are general enough to be appropriate for a variety of topics and tasks. In addition, the tasks were designed with the intention of evaluating these specific constructs of speaking. Incorporating a range of 1-5

for each evaluated aspect is beneficial because it leaves room for a variety of performance levels to be assessed. This rubric was used for each oral task. The total number of points for the speaking portion of the test is 30, and the parameters for establishing proficiency level performance results are the following: 1-12 points for novice-level, 13-24 points for intermediate-level, and 25-30 points for advanced-level performance.

Furthermore, with the consent of the participants, each oral test was recorded in order to extensively analyze performance. After listening to each recording, the administrators would fill-out the rubric together based on their shared perceptions of student performance.

H. Results and Discussion

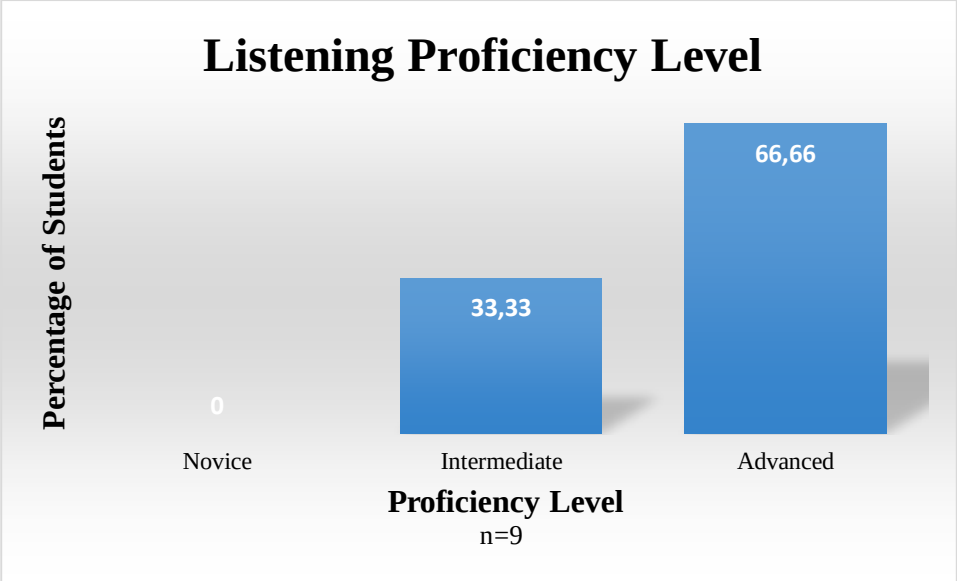
This section discusses the most pertinent information gathered from collecting the data according to the purpose of the study. This segment is organized into three sets of results: listening skills, reading skills, and speaking skills. Within each section there is analysis and discussion of how students performed as a group and individually for each target macro-skill. A general discussion regarding individual results and a comparative analysis will follow.

1. Listening Skills

The first section of the diagnostic test included a series of listening tasks in order to assess students' ability to demonstrate their listening comprehension for simple chemistry-related speeches. Students were given the opportunity to listen to each audio clip three times in order to answer the comprehension questions. Part I tasks corresponded to novice-level listening proficiency (according to the ACTFL) and consisted of five follow-up

questions, while Part II tasks corresponded to intermediate-level listening proficiency (according to the ACTFL) and consisted of ten questions; Part III tasks corresponded to advanced-level proficiency (according to the ACTFL) and consisted of four follow-up questions. Although efforts were made to introduce more challenging content and vocabulary as task difficulty increased (to reflect each target proficiency level), time constraints allowed for only a few types of items per section. Thus, the test results suggest that 66.66% of the participants were able to successfully complete all listening tasks up to the advanced-level tasks, while 33.33% were able to successfully carry out the intermediate-level tasks._Figure 1 shows the overall test results of the group.

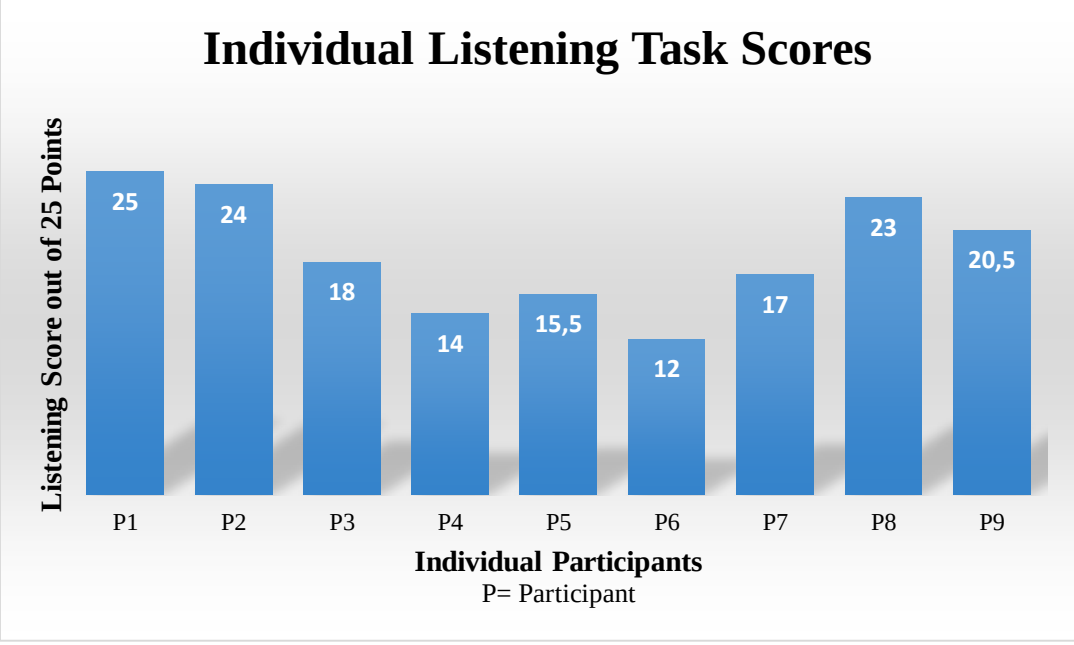
Figure 1. Listening test scores



The delivery rate may have affected some students. Although 66.66% of the participants scored in the advanced range, 33.33% scored in the lowest position because their performances were incomplete. This fact may have been due to the organization of the audios. The first audio was paused and with short utterances, while the last audio had a normal delivery rate, which could have been a difficulty for the participants.

Figure 2 displays the individual scores per participant in the listening section. The parameters for novice-level performance were 1-6 points, and for an intermediate-level performance 7-16 points; the parameters for an advanced performance were 17-25 points. Figure 2 demonstrates the points each participant scored out of a total of 25 points, which was the maximum amount and corresponded to an advanced-like level of proficiency. When looking at Figure 2, we can see that six participants scored within the advanced-level listening parameters; however, the results within this category vary. This is due to the fact that some participants did not finish the final listening tasks, and those who did finish did not score perfectly on all items. Therefore, even though results show overall high results in the listening section of the proficiency test, we cannot assume that students can perform at an advanced level.

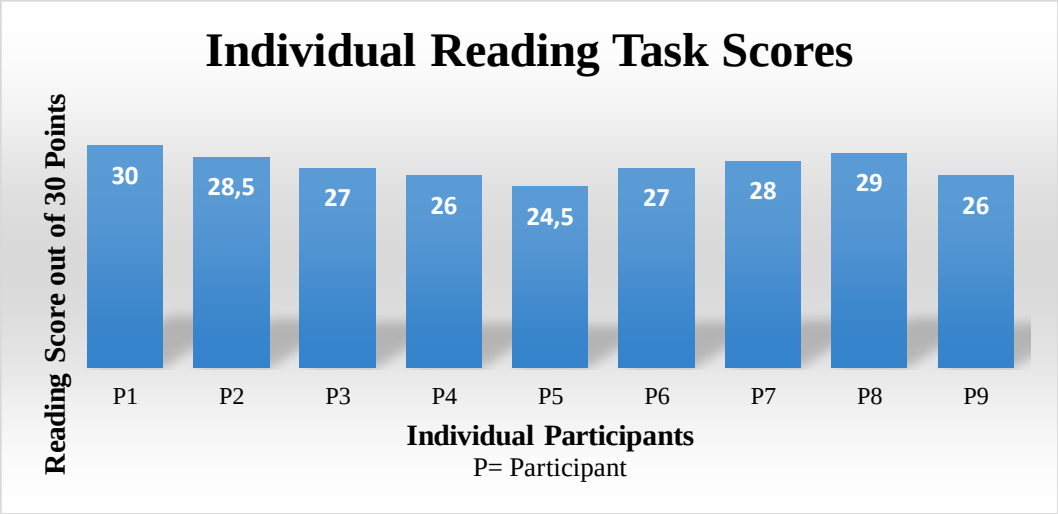
Figure 2. Individual listening task scores



2. Reading Skills

The second section of the diagnostic test was designed to assess the participants` reading proficiency related to chemistry-based texts. This section consisted of three reading tasks, each selected to reflect a specific level of reading proficiency according to the ACTFL (novice, intermediate, and advanced). Part I consisted of nine items following the reading and analyzation of a chart, and Section II consisted of ten items (both open-ended and closed-ended) following the reading and analysis of a short article. Similarly, Part III required students to read the introduction and conclusion of an article, and complete six items, of which two required the completion of a graphic organizer. For the reading section of the test, a total of 30 points was possible to attain. All of the participants scored within the advanced-level parameters, which may suggest a high reading proficiency. The parameters for an advanced performance was a score between 21-30 points. Test results indicate that 100% of students received a score at the upper level of the parameters, which demonstrates their ability to comprehend different types and levels of chemistry-related tasks. Figure 3 displays the individual scores on the reading section of the test.

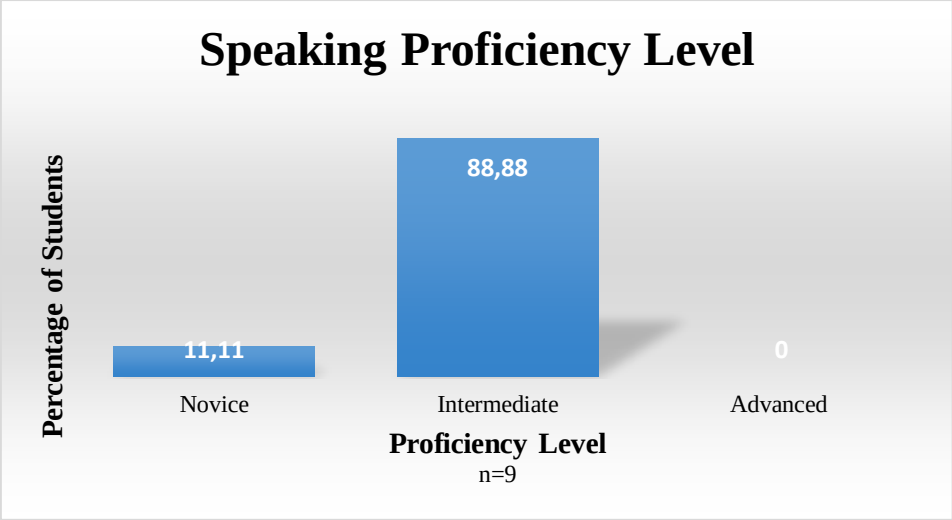
Figure 3. Individual reading task scores



3. Speaking Skills

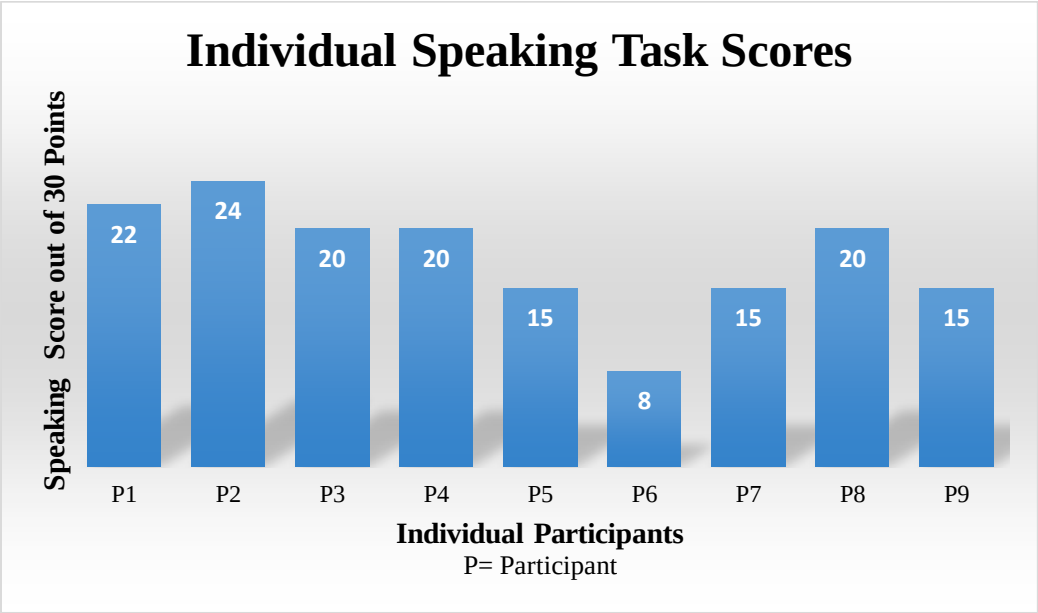
In order to assess the participants' oral proficiency, like the previous sections, the speaking section consisted of three parts that were designed to reflect novice, intermediate, and advanced proficiency levels according to the ACTFL.

Figure 4. Speaking test scores



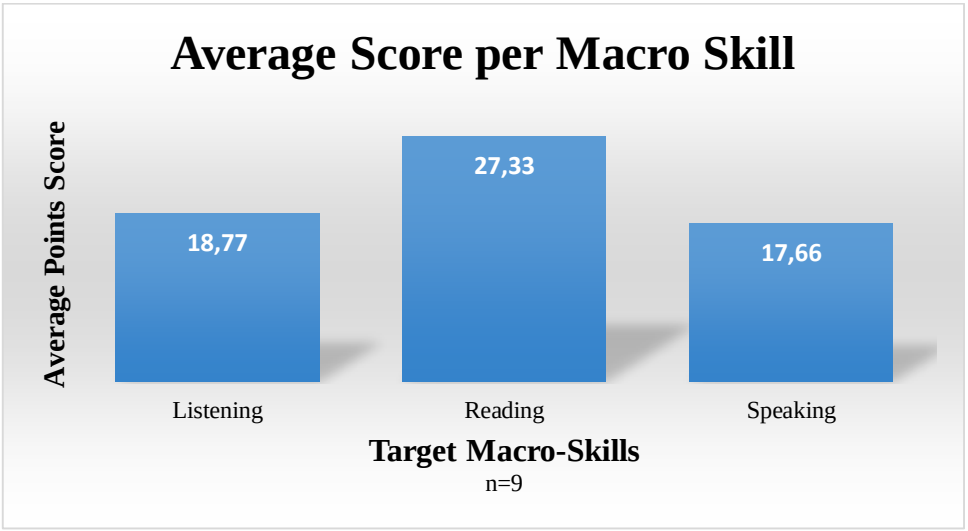
As displayed in Figure 4, 11% of the participants scored within the novice parameters (1-12 points) while 89% scored within the intermediate-level parameters (13-24 points), and zero participants scored within the advanced-level parameters (25-30 points). Test results indicate that of the eight participants who scored at the intermediate-level, five received a score on the upper level of the parameters, which may suggest higher proficiency. The remaining three scored on the lower end of the parameters, which may suggest that they found the tasks challenging. Figure 5 displays the individual scores on the speaking section of the test.

Figure 5. Individual speaking task scores



When comparing the average results per macro-skill, we can see a general picture of the group`s overall level of proficiency. Although it is crucial that we meet the needs of each individual participant and tailor tasks based on their specific needs, it is beneficial to have a general understanding for course design purposes. Figure 6 shows the average score of points per target macro-skill.

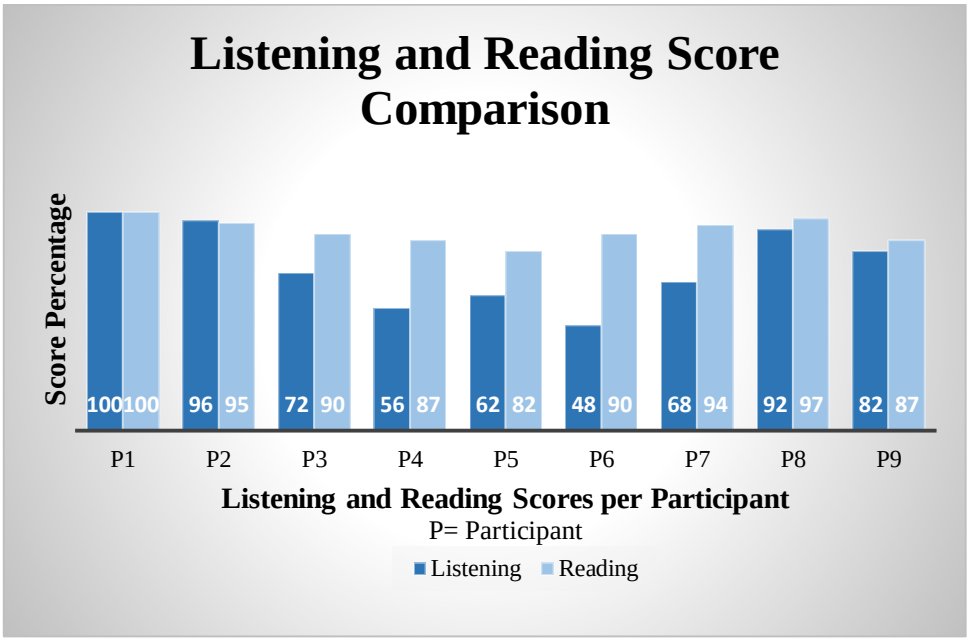
Figure 6. Average score per macro-skill



The results indicate that the average score of the listening section is 18.7, which falls within the advanced parameters of 17-25 points. This suggests that most of the students can complete an intermediate-level task even though their performance may not be 100% accurate. The score falls closer to the lower end of the parameters. The average score for the reading section of the test is 27.3, which falls within the advanced-level parameters of 21-30 points. This average is relatively high within the parameters and indicates a strong reading comprehension performance on the assigned tasks. Lastly, the average score of the speaking section is 17.6, which falls into the intermediate-level parameters of 13-24 points. Within these parameters, the results are average, and indicate an overall performance on the intermediate-level tasks.

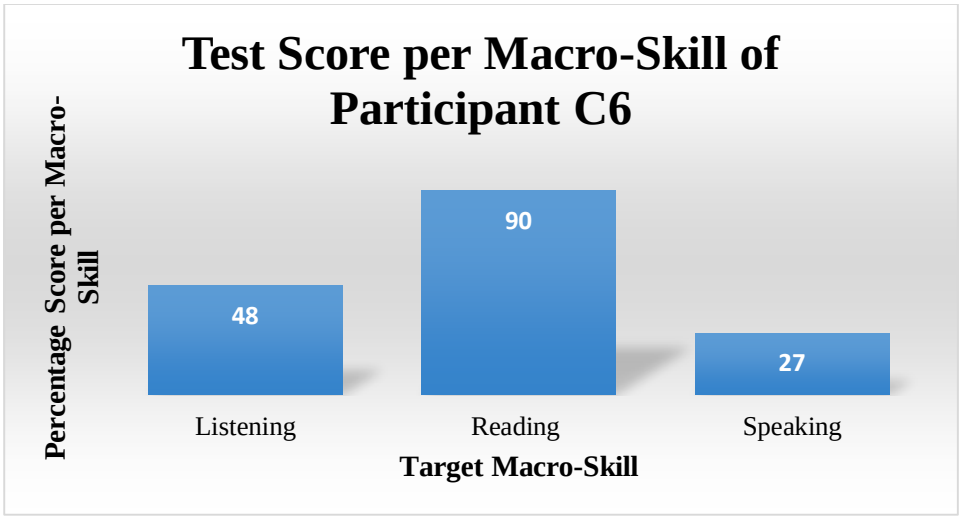
Furthermore, by comparing individual results we can see that 67% of participants who scored within the advanced-level parameters for the listening tasks also scored within the advanced-level parameters for the reading tasks indicating high receptive abilities. Figure 7 demonstrates the relationship between reading and listening test scores within the advanced-level parameters. Although a close relationship is shown, it is evident that students performed higher on the reading tasks, indicating stronger reading ability. These reading scores may be a result of frequent exposure to academic texts and articles that the participants read on a regular basis. In addition, the results show that Participants C3 and C7 scored lower in the parameters compared to the others, which could suggest that they scored within the advanced-parameters due to their prior knowledge of the subject matter as opposed to their understanding of the material.

Figure 7. Reading and listening score comparison for advanced-level results



Overall, the test results show an intermediate to advanced level of proficiency for the listening, reading, and speaking macro-skills. The only exception to this generalization is the case of Participant C6, whose test scores are displayed in Figure 8.

Figure 8. Test score per macro-skill of participant C6



The results demonstrate a low level of performance in the speaking section, and a score in the middle of the novice parameters. This participant also had the lowest score of the group in the listening section of the test. Although affective factors such as the level of confidence should be taken into consideration, it is evident that this participant had a more difficult time completing the speaking and listening tasks compared to the rest of the group. Participant C6 demonstrated strength in reading, and this may be because she is close to finishing the program, and has had a lot of exposure to English texts.

With the exception of Participant C6, all participants were able to successfully complete most of the tasks for all sections of the diagnostic test. The greatest strength appears to be in reading skills, with Participant C1 outperforming the group with a score of 100%, while the lowest score was obtained by Participant C5 at 82%. The participants also appear to be strong in listening skills, for which Participant C1 obtained the highest score of 100%, and Participant C4 obtained the lowest score at 56% while still falling within the intermediate-level parameters. The greatest weakness appears to be in speaking skills, for which no participants scored within the advanced-level parameters, and the highest score was 80% obtained by Participant C2 and the lowest score was 27% obtained by Participant C6. Generally speaking, students demonstrated linguistic weakness in pronunciation of chemistry-related words during the speaking assessment. A lack of vocabulary and ability to use grammar structures was also evident when the students were trying to express ideas and describe procedures. Furthermore, the rate of delivery in a listening task seemed to cause interference with comprehension, as students were not able to follow the ideas presented.

4. Conclusions about the Diagnostic Test

After careful analysis of the results discussed above, it appears that an effective course for this population would be one that focuses primarily on the development of speaking and listening skills. The speaking section of the test obtained the lowest scores overall, and almost all participants fell within the intermediate-level parameters. Furthermore, all participants had previously expressed a strong desire to further develop their speaking skills since they felt that it was the area in which they lacked the most proficiency. Hence, a course for this population should include a variety of chemistry-related and intermediate-level speaking tasks with ample input to help students acquire vocabulary. The aim should be to equip students with effective learning strategies, and guide them towards communicative competence while helping them build confidence. Tasks should help students develop accuracy (grammatical structures such as the imperative form), fluency, and pronunciation of high-frequency chemistry vocabulary. Similarly, there appears to be a need to focus on developing listening skills since there were mixed results in this section. Although participants' scores fell within the parameters of intermediate to advanced levels, there was a wide range of scores, which could indicate that some relied on background knowledge. Listening tasks in the course should aim to help students recognize chunks of language, take notes, and be able to cope with different rates of delivery. A variety of audio texts, accents, and topics should be provided as input to help the students develop their ability to listen and comprehend information.

The participants demonstrated a considerably high level of reading proficiency, and this is mainly due to the plethora of English chemistry-related texts that they are required to read in their program. As a result, the ESP course should not focus on developing this macro-skill, as the students already know how to cope with reading. This aligns with the

participants' preferences as outlined in the needs analysis. Academic articles and other texts will, however, be used as a source of input for class activities, but not for assessment purposes.

The results from this diagnostic test have been important in providing guidance on how to develop an appropriate and engaging course that meets the needs of this population of chemistry students. The goals and objectives will be geared towards the development of speaking and listening skills, as well as the acquisition of vocabulary. It can be stated that the diagnostic test is the direct result of matching the needs that the target population has with the proficiency levels and their characteristics that ACTFL has described in detail. This combination will enable planning of tasks specifically designed for the target population, and tailoring them to the different and possible proficiency levels that each participant has in each macro-skill.

CHAPTER II

Syllabus Design

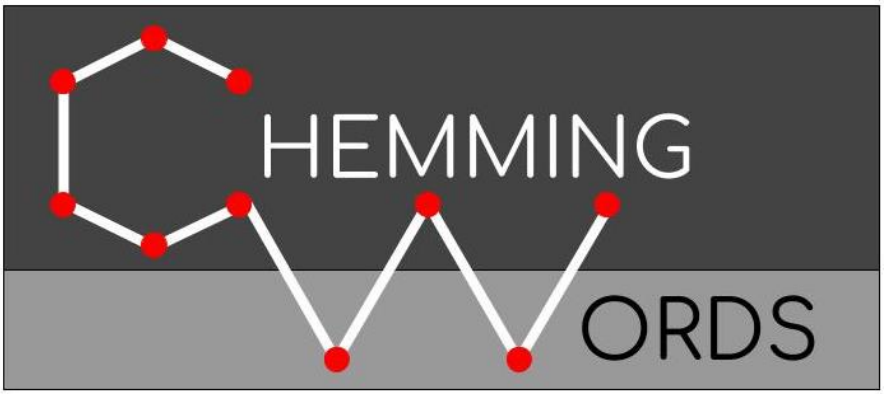
A. Course Name

The name of the course is Chemming Words. Etymologically, the word chemistry has several meanings. For instance, according to Trimble (1930), one possible origin is from the Egyptian word Khem which means black. However, for this same author, the word chemistry is more likely to come from the Greek word chyma that means ingot. On the other hand, English Language & Usage (2017) states that “the term chemistry [is] used to indicate an art rather than a science. That is probably why in the formation of the term the suffix - ry, meaning 'art of, ' was chosen” (n.p.).

B. Course Logo

The logo of the course is made up of two parts, the name of the course and the bond-line structural representation of organic chemistry. This representation follows certain rules which were the source of inspiration to come up with the logo. Chemistry Stack Exchange (2016) indicates that in bond-line representation, the *C* for carbon atoms is omitted as well as the *H* for hydrogen atoms on carbon. Instead of explicitly labeling the carbon atom, a carbon atom is represented by a "bend" or a "stick." Therefore, The C and the W in Chemming Words follow the bond-line structural representation of organic compounds. Dots were added in the vertices to simulate the tridimensional representation of an atom in a particular molecule. Figure 9 illustrates the logo.

Figure 9. Logo of the course.



C. Course Description

Chemming Words, a speaking and listening course for students of chemistry, was designed with the purpose of developing communicative competence by focusing on the improvement of speaking and listening skills. Targeting a population that seems to have an intermediate level according to the ACTFL proficiency guidelines, this course will follow the Task-Based Approach to language learning with the intent of providing real-world input to promote the use of authentic language within the classroom setting (Richards & Rodgers, 2001, p. 223). Tasks and their desired outcomes will all promote the development of speaking and listening skills, along with the ability to interact in social academic settings such as conferences. In addition, emphasis will be placed on the acquisition of relevant chemistry vocabulary. Through the completion of task-cycles, students will learn to identify main ideas and general messages in a speech, give an academically structured speech to an audience, and interact with chemists and chemistry students at a conference. Furthermore, tasks will often foster "processes of negotiation, modification, rephrasing, and experimentation" (Richards & Rodgers, 2001, p.223). This collaboration will be through group and pair work, games, and whole-group activities. This course consists of three units, and aims to develop students' level of confidence when speaking and interacting with

others, and provide individualized feedback to promote success. Likewise, TBLT favors the use of authentic materials to support authentic tasks (Richards & Rodgers, 2001, p.237). These materials will provide meaningful input to perform the planned tasks.

This course was designed for a population of 9 to 12 undergraduate students from the School of Chemistry at the University of Costa Rica. The population mainly consists of students in their second year of studies; however, there are students at higher levels as well. Based on the results of a chemistry-related diagnostic test, students are able to handle speaking tasks with moderate proficiency, and listening tasks with moderate to high proficiency. Results from the needs analysis indicate that these are the macro skills that should be addressed in the course. Nevertheless, for the purpose of this course, reading will serve as a complementary macro skill to provide input for the tasks, such as the reading and analysis of an academic article or newspaper report. Writing will be included as a part of self-assessment and reflection in the Assessment Portfolio, and will play a minor role. Students will be asked to express their opinions and ideas in written form, but their writing skills will not be targeted for evaluation. Therefore, the four macro skills will be integrated in the course in different ways and to different degrees.

This is a three-hour course that will take place on Wednesdays from 5:00 pm to 8:00 pm at the School of Chemistry at the University of Costa Rica in room XXX, and two instructors from the Master's Degree in Teaching English as a Foreign Language program will design, implement, and assess all academic aspects. In each lesson, one student teacher will assume the role of the lead teacher while the other will be an assistant teacher. A student-version of the syllabus was created (see Appendix F).

D. Statement of Goals and Objectives

The course will consist of three units; the following are the course goals and objectives that aim to foster the development of moderate to high proficiency levels of speaking and listening skills, as well as to promote the acquisition of vocabulary.

1. Unit 1

Goal: By the end of the unit, the students will be able to demonstrate comprehension of academic chemistry-related audio clips, presentations, and speeches by analyzing meaning and structures.

General Objectives:

By the end of the lesson, students will be able to:

1.1 effectively identify the global meaning in an academic speech related to chemistry by taking notes and filling in graphic organizers.

1.2 effectively identify the supporting details in an academic speech related to chemistry by taking notes and filling in graphic organizers.

1.3 adequately identify cohesive devices and connectors in an explanation by analyzing a speech transcript.

2. Unit 2

Goal: By the end of the unit, students will be able to interact with intelligibility and comprehensibility with members of the science community in a formal conference setting regarding chemistry-related topics.

General Objectives:

By the end of the lesson, students will be able to:

2.1 appropriately request information from a speaker by asking specific direct questions about a topic presented at a conference.

2.2 appropriately request information from a speaker by asking indirect questions about a topic presented at a conference.

2.3 adequately ask for clarification by repeating, restating, and summarizing ideas.

2.4 interact with participants at a conference by correctly stating an opinion about the topic of the conference.

3. Unit 3

Goal: By the end of this unit, students will be able to deliver effective speeches about chemistry to an audience of chemistry students, chemists, and stakeholders by communicating information in a clear and concise manner.

General Objectives:

By the end of the lesson, students will be able to:

3.1 appropriately deliver a short speech by conveying the global idea and supporting details in an academic manner.

3.2 appropriately use cohesive devices and connectors in an explanation by organizing the target words into a speech.

3.3 accurately answer questions in a clear and concise manner regarding chemistry-related topics by simulating a conference questions-and-answers session.

E. Methodology

1. Approach

The approach that this course encompasses is based on communication as the center of language learning, and is called Task-Based Language Teaching (TBLT). According to Willis & Willis (2007, p.7), TBLT focuses on real language use within the classroom, and encourages learners to discover and use language in meaningful ways. Language learning is seen as a process in which students interact with input and with each other to negotiate meaning and reach a specific meaningful outcome. This approach is concerned with the functions of language rather than the grammatical structures. In Task-Based Language Teaching, emphasis is placed on meaning as opposed to accuracy (Richards & Rodgers, 2001, p.226). When working within this approach, it is of great importance to view fluency as a primary goal, promote intrinsic motivation, focus on meaning and the negotiation of it, exploite authentic material, prioritize effective communication, and utilize scaffolding to foster acquisition (Richards & Rodgers, 2001, p.226).

This method is suitable for the design and development of materials for this particular course because it emphasizes the production and use of real-world language that is relevant to the needs of the student population. Chemistry students require English for specific situations in their academic and future occupational fields. One of these situations includes being able to give a speech at a conference and being able to interact in a formal conference setting with other chemists or chemistry students. Therefore, it is useful to prepare them by providing the opportunities to thoroughly engage in those same tasks, while giving them the tools and guidance they require to succeed. This approach is effective because it focuses on both input and output processing in order to maximize student language acquisition, and so they go hand in hand, demanding the development of

both receptive and productive skills. The task-based cycle consists of stages that promote the discovery of language through meaningful interactions that serve a purpose. Salient characteristics of this cycle include a one-way or two-way exchange, collaboration, competition, multiple outcomes, simple and/or complex language, as well as both reality-based and pedagogical activities (Richards & Rodgers, 2001, p.231).

2. Classroom Dynamics

The benefits of team teaching are several. When working within a task-based framework there are several components that will require great attention, and as a result, students will require ongoing support. Team teaching allows for sharing workload, and so promotes efficiency. Rotations will take place on a class-by-class basis in which one student-teacher will lead the group while the other assists and provides support. The role of supporter will include many responsibilities, such as modelling dialogues with the lead teacher, participating in group tasks with the students, providing remedial support and guidance for students, and monitoring and providing feedback to students throughout the task cycle. Likewise, the lead teacher will be responsible for executing and assessing the different phases of the task cycle, providing clear instructions, motivating the students, along with monitoring and providing feedback.

3. Tasks and Techniques and their Rationale

The TBLT method encourages the development of tasks and activities that foster spontaneous participation from the student, and allow for opportunities to make errors (Richards & Rodgers, 2001, p.228). Activities should incorporate vocabulary and lexical units in order to help students become better equipped for interactions. In order to promote understanding of, and success in, a specific task. The TBLT approach encourages background activation activities and pre-tasks prior to completing the target task itself

(Richards & Rodgers, 2001, p.236). This series of activities helps students to activate schemata and use prior knowledge to draw meaningful connections that may support task completion. Following the main task is often a post-task and an out-of-class task in which students can use the target language on their own. An example of a task cycle for low-proficiency students is the following:

1. Background activation: Students work in pairs to brainstorm the term "periodic table" and create a semantic map of all known terms associated with this topic.
2. Pre-task: Students are told they will watch a video about the periodic table and that they must listen for the terms they had listed on their semantic map. They will then watch the video a second time, and try to listen for the main idea. In pairs, the learners will compare their notes. They will watch the video a third time and then have a whole-class discussion to check for overall comprehension. The purpose of this pre-task is to expose learners to vocabulary and ideas they will need to succeed in the main task.
3. Task: Students create a role-play in which they discuss the basic properties of elements in the periodic table with a partner.
4. Post-task: Students write a one-paragraph description of the atomic structure of three elements and their basic properties; they can add some drawings. They will be told that they will present this information to an audience of high school chemistry students.

Common tasks that will be carried out in this course include having discussions, giving a speech, explaining the steps in a process, providing a formula, solving a chemical problem, and conference simulations. Several tasks will be executed individually, as this

mimics real life scenarios when chemistry students and professionals are required to present information and research. However, many of the tasks will be done in pairs or small groups of three to four students in order to facilitate collaborative learning and teach students how to interact in formal settings. In addition, these activities allow students to engage in meaningful interactions and negotiate meaning so that they can acquire the language in a personalized manner. This method considers authentic input to be valuable, and realia (such as newspapers, academic articles, and videos) is considered to be effective since it exposes learners to real life material and situations (Richards & Rodgers, 2001, p.237). As a result, the course will include an array of input from authentic sources, especially Ted Talks, podcasts, and Youtube videos to engage the students and expose them to different accents, rates of speech, and vocabulary. Other collaborative and communicative tasks that will be utilized in this course at varying stages in the task cycle include jigsaw tasks, information-gap tasks, and decision-making tasks.

4. Role of the Learners

A TBLT lesson is a student-centered one. Hence, learners working within the TBLT approach play a role as active participants, and are encouraged to engage in spontaneous interaction while going through the stages of the task cycle (Richards & Rodgers, 2001, p.235). Since meaningful communication is crucial, it is important that learners interact with their peers in pairs and/or in groups (Richards & Rodgers, 2001, p.235). Through this interaction, students can develop important micro skills such as negotiating meaning, asking for clarification, and guessing meaning from context. Students, therefore, will be encouraged to take risks while engaging in conversation. Learners will be trained to recognize the value of learning from one's errors, and will be given opportunities to pay attention to form, as well as to notice how language is used in specific contexts.

5. Role of the Instructors

The role of the instructor in TBLT is active and involves the planning and development, execution, assessment, and evaluation of each lesson plan. The instructor is a facilitator throughout the task cycle (Richards & Rodgers, 2001, p. 236). Teachers are responsible for developing meaningful tasks that incorporate authentic materials (such as realia) and planning the various stages of the task cycle so that students will succeed. It is also imperative that instructors plan and develop lessons based on the careful analysis of the students' needs and wishes. Background activation warm ups and pre-tasks are important phases of the task cycle that the instructor must take into consideration while planning. These phases serve the purpose of activating students' schemata so that they can use their prior knowledge to perform well on the task and know what to expect. Knowing what to expect may help decrease their cognitive load, and therefore, enable them to pay more attention to new forms and to the negotiation of meaning during interactions (Richards & Rodgers, 2001, p.236).

F. Assessment

English for Specific Purposes courses focus directly on learner needs. In order to evaluate the success of a course, and whether or not students' needs were met, it is imperative to think carefully about assessment and the role it plays throughout the course. Dudley-Evans and St John (1998) define assessment as "a process of measurement" which is "important for feedback on learning" (p.210). Similarly, Nunan (2004) considers assessment as procedures to collect learner data (p.138). Indeed, Nunan (2004) states that "assessment is thus a subset of evaluation" (p.138). For this same author, "Assessment subsumes testing and is, in turn, subsumed by evaluation" (p.138).

The Chemming Words course will use formative evaluation, which is "to find out what is working well, and what is not, and what problems need to be addressed" (Richards, 2001, p. 288). Since this process takes place during the course, it allows for the correction of possible shortcomings that may appear in the course. Keeping this purpose in mind, ESP Chemming Words will use formative evaluation to assess each unit of the course.

The evaluation of the ESP course will follow both informal and formal assessment. According to Brown (2004), informal assessment can have a number of forms, from comments to impromptu feedback (p.17). Moreover, this same author claims that "informal assessment is embedded in classroom tasks designed to elicit performance without recording results and making fixed judgments about a student's competence" (p. 17). Informal assessment is an effective tool to keep track of the students' performances and help the students with healthy language growth while they are performing their tasks. Thus, informal assessment will help the ESP students to quickly correct any salient mistakes without affecting their final grade.

On the other hand, formal assessments "are systematic, planned sampling techniques constructed to give teacher and student an appraisal of student achievement" (Brown, 2004, p.17). The most common form of formal assessment is a test. However, Brown (2004, p.17) suggests the use of journals and oral presentations as forms of formal assessments. Assessing progress is important because, according to Graves (2000, p.278), it is a way of "finding out what the learner has learned with respect to what has been taught at different points in the course." Regarding this point, Brown (2004) agrees with the aforementioned point by stating that "summative assessment aims to measure, or summarize, what a student has grasped, and typically occurs at the end of a course or unit of instruction" (p.17). Furthermore, Brown (2004) considers formative

assessment as a way of "evaluating students in the process of 'forming' their competencies and skills with the goal of helping them to continue that growth process" (p. 17). Hitherto, four assessment concepts have been presented theoretically, and they will have a practical realization in the ESP course.

Since the course is organized into three main units, at the end of each unit, students will be formally assessed by performing a task similar to the ones that will have been addressed in the unit. This assessment will also be summative. Summative evaluation "seeks to make decisions about the worth or value of different aspects of the curriculum" (Richards, 2001, p. 291). According to Richards, summative assessment can have different forms: a) mastery of
objectives (to what extent the objectives of course have been achieved), b) performance on tests (formal tests to measure achievement), c) measure of
acceptability (how enthusiastic students are), d) retention rate (enrolment), and
e) efficiency of the course (how straightforward the course is) (p 292). The Chemming Words course will use performance tests to assess learners summatively. At the end of each unit, students will "perform an activity which simulates a performance they will have to engage in outside the test situation" (Nunan, 2004, p. 145).

Time is a constraint in an ESP course; Dudley-Evans and St John (1998) state that "in many ESP situations tests may be inappropriate: in a short intensive course the time is needed for input and practice; the real effect is likely to show itself some time after the course" (p. 210). The authors also claim that "the ultimate proof for an ESP course is how well the learners fare when using English in their target situations; after the course they should be more effective and more confident using English in their target situations" (p. 210). Consequently, since the Chemming Words course will last 14 sessions, it will have

three performance task assessments. However, during the development of each unit, students will be assessed formatively, which means that learners will have enough practice, correction, and training to assimilate the necessary language in order to succeed in the formal assessment tasks at the end of each unit.

Consequently, the ESP students will have to perform three formal summative assessment tasks. At the end of Unit One, students will have to demonstrate comprehension of academic chemistry-related oral utterances by identifying general ideas, supporting details, speakers' attitude and tone, structure of a speech, and cohesive devices and connectors. Learners will have to do this by taking notes and creating a graphic organizer.

Similarly, at the end of Unit Two, students will have to ask questions directly and indirectly about a chemistry fact that will have been presented in a conference format. Learners will be required to develop direct and indirect questions to engage with the speakers at a conference and get extra information. In this final task, students will demonstrate that they are able to express inquiry and ask questions in an academic manner. Emphasis will be placed on appropriate interactions with correct use of register.

Then, at the end of Unit Three, learners will have to interact with the scientific community in the form of a conference. Thus, learners will have to present chemistry topics in a conference, and they will be asked questions regarding the topic that they have just talked about. This way, they will be engaged in a chemistry- related conversation. These three summative formal assessment tasks will form the main core of the learners' evaluation.

The Chemming Words ESP course will use authentic assessment. "Authentic assessment is a form of assessment in which students are asked to perform real-world tasks that demonstrate meaningful application of essential knowledge and skills," (Mueller, 2005,

p. 2). Chemming Words promotes the use of authentic assessment through the design of student portfolios. Nunan and Wong, as cited in Nunan (2004, p. 160), indicate that a portfolio has four parts, which include:

1. a self-introduction (overview and rationale of the author)
2. samples of both spoken and written language
3. evidence of growth and development
4. evidence of reflective learning

The final component of evaluation is the development of an Assessment Portfolio. Abrutyn & Danielson (1997) state that an assessment portfolio consists of tasks that bring specific unit outcomes to life. By developing a portfolio, students will be able to demonstrate their ability to succeed when given specific tasks, and show that they have developed the target skills. (Abrutyn & Danielson, 1997). Perhaps the most important aspect of the assessment portfolio is the reflective component. Through the completion of weekly learning journals (for the duration of the course) and main task cover sheets (for each of the three main assessment tasks), students are required to show their ability to reflect thoughtfully upon the learning process and extent to which they succeeded in reaching the target outcomes (Abrutyn & Danielson, 1997). The portfolio will be summatively evaluated at the end of the course by the instructors in order to assess students' performance. According to Hismanoglu (2010), learners in an ESP setting have very specific needs to be met, and portfolios improve learner responsibility and autonomy which in turn help them to meet those needs. As a result, this course will integrate an assessment portfolio that promotes reflection, as it is believed to be the most effective for ESP learners who need to be more aware of their learning and development. Evidence of growth will be achieved by compiling weekly learning journals that will guide the students

to understand both their strengths and weaknesses (see Appendix J). Likewise, the creation of this portfolio will help students to condense the material studied in class in order to study for the performance tasks.

To conclude, the ESP course for chemistry students will be addressing the assessment key terms that the theory suggests. Student success in this course is based on the completion of the three main achievement tasks and the cumulative assessment portfolio. Attendance is important since skills and content required to perform each unit achievement task will be covered during class sessions. If a student is absent, it is his/her responsibility to get caught up with the class material by contacting the instructors. Absences will not directly affect the students' final grade; however, they may affect their ability to perform the final unit tasks. If a student misses an achievement task, it is his/her responsibility to contact the instructors to schedule a make-up assessment tasks. The following list shows how the learners will be assessed.

Achievement Task 1…….25 %

Achievement Task 2…….25 %

Achievement Task 3…….25 %

Portfolio …….25 %

Total……..100 %

G. Instruments

The Chemming Words course will use a series of instruments to evaluate the salient aspects of the course, such as student performance, overall course effectiveness, the effectiveness of the instructors, and the learning process. Thus, at the end of each unit, students will participate in a summative task assessment in order to evaluate the extent to

which they meet the goals and objectives of the unit. These tasks will be authentic in nature, and thus be based on real-world scenarios in which the students will likely find themselves in the future. Assessment tasks will include simulated conference speeches, and interactive and collaborative based tasks that would take place in a conference setting. Students will be given ample time to develop their final unit task, and to demonstrate that they have acquired the target skills. A rubric will be used by the instructor to formally evaluate each listening and speaking task performance (see Appendix E).

For course evaluation purposes, two assessment instruments will be used. One instrument will evaluate each unit; this instrument is called Unit Evaluation (see Appendix G). This survey has a Likert scale with 12 statements to rate, and three statements to complete according to students' likes, dislikes, and a general rating of the unit. The instrument Course Evaluation will elicit information regarding the course (see Appendix H). This survey has a Likert scale requiring students to evaluate 12 statements regarding the general development of the course. Moreover, students will complete three statements regarding expectation fulfillments, recommendations for a future course, and on a scale of one to ten, students will grade the course by choosing a number.

In order to assess the instructors, students will complete the Instructor Evaluation form (see Appendix I). This instrument consists of a Likert scale with 9 statements to rate the performance of each instructor. The students will also complete three statements to assess the influence of the instructors in the learning process. The students can provide suggestions for the instructors to improve, and they will also give a general rating of each instructor.

Furthermore, the completion of an assessment portfolio will play an integral role in the overall course assessment, as it will allow students an opportunity to reflect on the learning process and progress throughout each unit. Portfolios are believed to be an effective way of their promoting metacognitive awareness and autonomous learning which are essential things to have within an EFL environment (Yang, 2003, p.). Through portfolios, students can become active participants in the learning process by setting goals, making plans, and developing an understanding of their learning styles and effective strategies (Yang, 2003). According to Abrutyn and Danielson (1997), an assessment portfolio consists of tasks that bring specific unit outcomes to life. Through a portfolio, learners should be able to demonstrate that they have developed the target skills and reached the target goals, as well as demonstrate their ability to reflect thoughtfully upon the learning process and extent to which they succeeded in reaching the target outcomes (Abrutyn & Danielson, 1997). Furthermore, Hismanoglu (2010) states that the implementation of portfolios as a mode of assessment is quite useful in an ESP setting since learners have very specific needs that must be met, and portfolios improve learner responsibility and autonomy which in turn help them to meet those needs. Therefore, an assessment portfolio will be integrated into the Chemming Words course, as it is believed to be the most effective for EFL learners who need to be more aware of their learning and development.

Each student portfolio will consist of weekly learning journals (see Appendix J). At the beginning of each class session, the learning journal will give students an opportunity to first think and make predictions about what the upcoming lesson will entail, and thus set goals. At the end of the lesson, the students will then use the learning journal to reflect on

the content, vocabulary, skills, and strategies learned in class and the steps they can take to improve and build on that knowledge for the next class session. Moreover, at the end of each unit, each student will record their performance test; this recording will help the student to reflect on his or her learning process. The students will use the Unit Recording Self-Assessment form (see Appendix K) to complete the assessment portfolio. A set of ten questions will guide them to analyze their performances. The students will record their own analysis, and both the performance test and its analysis will be part of the assessment portfolio which will consist of six recordings totally. Finally, the students will write a brief introduction for the assessment portfolio to be completed (see Appendix L). In the introduction, the students will write what the portfolio is about and its purpose. The portfolio will be assessed by both the student for reflective purposes, and the instructor for evaluation purposes at the end of the course. The Portfolio Evaluation instrument will be used by the instructor to assess the students' completion and comprehension.

The aim of the assessment tools in this course will be to promote learner metacognitive awareness and autonomous learning. Students will be encouraged to be active participants in the learning process by setting goals, making plans, and assessing their own performance. Learners will be given the opportunity to evaluate the effectiveness of the course content and instructors, and express whether or not their needs were met. Ongoing formative assessment and opportunities for reflection will hopefully contribute to a healthy educational environment in which learning takes place.

H. Contents

This course aims to develop the speaking and listening skills of moderate-level proficiency chemistry students. Meaningful interactions will be prioritized and vocabulary acquisition will be emphasized throughout each lesson of the course. Due to the time allotted for the execution of the course, the content has been divided into three units described below. The general objectives for each goal are listed chronologically, but a particular lesson may make use of various objectives at once. The lessons plans are completely developed in Appendix M.

Chart 1. Unit 1 goal and objectives

Unit 1: Listening to Chemists	
Goal	By the end of the unit, the students will be able to demonstrate comprehension of academic chemistry-related audio clips, presentations, and speeches by analyzing meaning and structures.
General Objectives	By the end of the lesson, students will be able to: 1.1 effectively identify the global meaning in an academic speech related to chemistry by taking notes and filling in graphic organizers. 1.2 effectively identify the supporting details in an academic speech related to chemistry by taking notes and filling in graphic organizers. 1.3 adequately identify cohesive devices and connectors in an explanation by analyzing a speech transcript.

Chart 2. Unit 1 content

Unit 1: Listening to Chemists

General Objective	Tasks	Skills	Language Focus	Strategies	Allotted Time
1.1	Identify the global meaning of a speech in an academic presentation	L	Vocabulary Chemists Bonds Molecules Hydrogen Atoms Elements Protons, Neutrons, Electrons Nucleus Useful language The main idea is… I believe that ….. What do you think about…. Did he/she say…? It is important to mention….	Retain chunks of language	1 lesson
1.2	Identify the supporting details of a speech	L	Vocabulary Titanium Atomic number Mass number Boiling Point Melting Point Luster Useful language Titanium is… Titanium has… I believe that… It means…. What do you think about ____? I heard….. I believe he/she said…..	Retain chunks of language Recognize grammatical word classes	1 lesson
1.3	Identify cohesive devices and	L	Vocabulary Cohesive devices: also, equally, and,	Recognize grammatical word classes	0.5 lesson

	connectors in a speech transcript		furthermore, for instance, such as, therefore, thus Substance Compound Solution Distillation Mass <u>Useful language</u> The word ____ was used to….. I heard the speaker say…..		

Chart 3. Unit 2 goal and objectives **Unit 2: Asking for Chemistry Information**	
Goal	By the end of the unit, students will be able to interact with members of the science community in a formal conference setting regarding chemistry-related topics with intelligibility and comprehensibility.
General Objectives	By the end of the lesson, students will be able to: 2.1 appropriately request information from a speaker by asking specific direct questions about a topic presented at a conference. 2.2 appropriately request information from a speaker by asking indirect questions about a topic presented at a conference. 2.3 adequately ask for clarification by repeating, restating, and summarizing ideas. 2.4 interact with participants at a conference by correctly stating an opinion about the topic of the conference.

Chart 4. Unit 2 content

Unit 2: Asking for Chemistry Information Content

General Objective	Tasks	Skills	Language Focus	Strategies	Allotted Time
2.1	Ask specific direct questions to members at an academic conference	L & S	<u>Vocabulary</u> Covalent Bond Binary Compound Polyatomic Ion Ionic Bond Chemical Reaction <u>Useful language</u> What is / are ….. When do / does …. Why is / are….. Is it … Are they… Does it … Do they	Produce English stress patterns Use grammatical word classes, systems, word order, patterns, rules, and elliptical forms Guess meaning from context Negotiate meaning	1 lesson
2.2	Ask indirect questions to members at an academic conference	L & S	<u>Vocabulary</u> Reactants Products Coefficients Combustion Reaction Synthesis Reaction <u>Useful language</u> Could you explain why… Could you tell us when… May I know why… Would you mind explaining why...	Produce English stress patterns. Use grammatical word classes, systems, word order, patterns, rules, and elliptical forms Guess meaning from context Negotiate meaning	1 lesson

2.3	Ask for clarification when interacting with members at an academic conference	L & S	<u>Vocabulary</u> Colloid Conductivity Polymerization Titration Sublimation <u>Useful language</u> In other words, you are saying that… Do you mean that… When you say …, you mean that...	Produce English stress patterns Use grammatical word classes, systems, word order, patterns, rules, and elliptical forms Guess meaning from context Negotiate meaning	1 lesson
2.4	State an opinion about a topic at an academic conference	L & S	<u>Vocabulary</u> Chemical formula Semiconductors Allotropes Sublimation Diatomic molecule <u>Useful language</u> I think that… I would say that…	Produce English stress patterns Use grammatical word classes, systems, word order, patterns, rules, and elliptical forms Guess meaning from context Negotiate meaning	1 lesson

Chart 5. Unit 3 goal and objectives

Unit 3: Interacting with Chemists

Goal	By the end of this unit, students will be able to deliver effective speeches about chemistry to an audience of chemistry students, chemists, and stakeholders by communicating information in a clear and concise manner.
General Objectives	By the end of the lesson, students will be able to: 3.1 appropriately deliver a short speech by conveying the global idea and supporting details in an academic manner. 3.2 appropriately use cohesive devices and connectors in an explanation by organizing the target words into a speech. 3.3 accurately answer questions in a clear and concise manner regarding chemistry-related topics by simulating a conference questions-and-answers session.

Chart 6. Unit 3 content

Unit 3: Interacting with Chemists

General Objective	**Tasks**	**Skills**	**Language Focus**	**Strategies**	**Allotted Time**
3.1	Convey the global ideas and supporting details in an academic speech	S	<u>Vocabulary</u> Polymers Physical Properties Waste Generate Emissions Toxicology Hazard <u>Useful language</u>	Produce chunks of language of different lengths Produce English stress patterns Use grammatical word classes, systems, word	1 lesson

			Let's talk about…. The purpose of this talk is to…. It is important to consider…. We would like to emphasize….	order, patterns, rules, and elliptical forms	
3.2	Use cohesive devices and connectors in an academic speech	S	<u>Vocabulary</u> Solvant Solubility Saponification Precipitate Oxidize Isomer Discourse markers: I mean, so then, as I said, you know, in addition, conversely, furthermore, firstly, secondly…. <u>Useful language</u> Our presentation is about…. Today we will discuss….. First, let's look at….. Lastly, it is relevant to mention….	Produce chunks of language of different lengths Produce English stress patterns Use grammatical word classes, systems, word order, patterns, rules, and elliptical forms	1 lesson
3.3	Answer questions clearly and concisely after presenting an academic speech	S	<u>Vocabulary</u> Immiscible Homogenous Fermentation Crucible Yield Surface Tension A is… B and C are… The molecule has… The chemical reaction produces...	Produce chunks of language of different lengths Produce English stress patterns Use grammatical word classes, systems, word order, patterns, rules, and elliptical forms	1 lesson

			<u>Useful language</u> I believe that... Research states that… According to… In my opinion… It is important to consider…		

I. Conclusion

The needs analysis conducted provided insight into the strengths, weaknesses, needs, and wishes of the target population. Thus, the course Chemming Words focuses on the development and improvement of speaking and listening skills with emphasis placed on vocabulary acquisition and pronunciation improvement. Students appear to have sufficient reading skills, so a reading focus will not be included in this course. Regarding content, the course will focus on real world/relevant tasks for chemistry majors with three speaking performance tasks at the end of each unit along with an assessment portfolio to promote self-reflection. There will be three units in total that focus on developing interactive and communication skills in order to succeed in a conference setting. Therefore, students will be equipped with the tools they will need to succeed, such as the ability to ask and answer questions in an appropriate manner, the ability to deliver an effective academic speech, and the ability to demonstrate comprehension while listening to a speaker during a presentation. With this focus, we aim to help students develop communicative competence, become active participants in the learning process, and feel confident while interacting with members of the chemistry community. Hitherto, Mauli Chinambu and Erick Oses conducted this research project. Henceforth, Erick Oses was in charge of it.

CHAPTER III

Pronunciation Problems

A. Research Question

A key element to acquire second language proficiency is pronunciation. Two positions stand for pronunciation teaching; one view considers that the purpose of pronunciation teaching is to eliminate foreign accent, while another view considers pronunciation teaching ineffective after a certain age (Avery & Ehrlich, 1992). Even worse, pronunciation has been neglected (Kelly, 2000, p. 13). Therefore, pronunciation teaching is important because pronunciation mistakes can inhibit successful communication. Constant pronunciation mistakes will result in difficulty for the listeners to understand and frustration for the speaker who might have good grammar and lexis, but pronunciation errors do not allow proper intelligibility. Avery and Ehrlich (1992) also state that "many pronunciation problems result from ESL students' inability to produce the different syllables types of English" (p. 53).

These facts should move ESL instructors to action because correct pronunciation is fundamental to achieve intelligibility. Indeed, Avery and Ehrlich (1992) state that teachers must focus on "critical errors," in other words, "features of a student's speech most responsible for incomprehensibility." This is the main issue; ESL teachers should provide instruction to students to overcome pronunciation problems. Consequently, to improve pronunciation to convey ideas and carry out oral transactions was one of the reasons that motivated a group of chemistry students to take an ESP course.

The needs analysis of this ESP population revealed that these students have problems with the pronunciation of the words related to their field. In their chemistry program, this population is assigned readings in English as a form of chemistry input. Hence, the written form of chemistry words is not a major problem because these students use tools to understand the meaning of the words: they use the transparency of some of the words, dictionaries, and translators. Nevertheless, this population struggles with the oral form of the words because the written and oral forms are often dissociated; the transparency between both forms is blurred. In this scenario, this population has to come up with an accurate pronunciation, whether they are reading silently, which is called "early phonological activation" (Alderson, 2000, p. 14) or when they need to express an idea orally. In order to limit the scope of study, this research focuses on segmentals (phonemes and syllables) and the suprasegmental feature of word stress. The aim of this research paper is to answer the following research question: What are the most common mistakes concerning the pronunciation of 80 chemistry-related words that a group of chemistry students make? Subsequently, the next questions are also addressed:

1. How are the pronunciation mistakes ranked based on their frequency?
2. What are the pronunciation changes concerning the letter "o"?
3. What is the ranking of the phoneme substitutions regarding the letter "o" in terms of frequency?

This study was carried out in two phases. During the first phase, the researcher investigated the main research question and subquestion 1. During the second phase, once the most frequent mistakes had been identified, the subquestions 2 and 3 were added. The pronunciation of the letter "o" has several phonemes in English. For a native Spanish

speaker, this letter represents a challenge since this letter stands for only one phoneme in Spanish; however, this letter stands for several phonemes in English.

B. Review of Literature

The written and oral forms of an English word do not always correlate as they do in Spanish; this might be the first impression that an English student, whose L1 is Spanish, might have at the beginning of the learning process. Vowels are the sounds that mostly represent a challenge regarding a correct pronunciation. Similarly, placing the word stress seems to be difficult, especially when a word has more than two syllables; the more syllables that a word has, the most difficult the challenge to stress the correct one is. This literature review starts with the definition of pronunciation. Then, the importance of teaching pronunciation is addressed. Afterwards, the features of consonant and vowel sounds are analyzed, and the concept of syllable is explained as well as that of word stress. Finally, possible origins of pronunciation errors, which are segmental and prosodic ones, are explored.

Pronunciation is one of the several aspects of knowing a word. Dalton and Seidlhofer (1994) define pronunciation as "the production of significant sound in two senses" (p. 3). In other words, correct pronunciation is necessary on the part of the speaker for the listener to understand properly. These authors consider that the utterance of phonemes is significant because sound is part of a code of a language, and is used to achieve meaning in context; therefore, sound, combined with other factors, makes communication possible (p. 3). Therefore, correct pronunciation is important to achieve communication, which is the ultimate goal of language.

Pronunciation is an important component of a language because it is one of the fundamental parts to achieve meaningful communication. Indeed, Nation (1990) and Thornbury (2002) have listed aspects regarding what knowing a word implies: the spoken form, the written form, the grammatical behavior, the word's derivations, collocations, register, connotations, frequency, and meaning(s). These aspects of knowing a word are stored in "a highly organized and interconnected fashion," which is called mental lexicon (Thornbury, 2002, p. 16). Similarly, Lewis (1998) states that the mental lexicon "is stored as prefabricated multi-word 'chunks' (p. 20), and part of the storage involves pronunciation. Thus, there are several issues involved in learning a word.

The explicit teaching of pronunciation is essential when a person is learning a new language. Moreover, Kelly (2000) states that language students "often show considerable enthusiasm for pronunciation. They feel it is something that would help them to communicate better" (p. 13). This author also states that "a learner who consistently mispronounces a range of phonemes can be extremely difficult for the speaker from another language community to understand" (p. 11); this is the main reason that pronunciation has to be taught. Consequently, this author has listed three necessities that pronunciation teachers have to be aware of: theoretical knowledge, practical classroom skills, and good ideas for classroom activities (p. 13). Correct pronunciation leads to effective communication.

To know pronunciation features is necessary in order to help students improve their speaking skills. In this regard, Kelly (2000) has broken down the constituent parts of pronunciation for a better understanding of this language feature. Thus, this author has divided pronunciation into two parts: phonemes and suprasegmental features. Phonemes

are divided into consonants and vowels. Consonants are classified into voiced and unvoiced, and vowels are separated into single vowels and diphthongs. At the same time, single vowels are divided into short and long. On the other hand, suprasegmental features are related to intonation and stress, and the latter has to do with word and sentence stress (p. 1). By knowing these features, the teacher can detect, address, and help learners improve pronunciation issues.

Both consonants and vowels have their own pronunciation features. According to Celce-Murcia et al. (2010), consonants are the solid blocks that words are constructed with while vowels are malleable material to construct language (p. 50). Concerning English consonants, they are classified according to voicing, place of articulation, and manner of articulation. Regarding voicing, consonant sounds are classified as voiceless or voiced. Concerning manner of articulation, consonants can be categorized as stop, fricative, affricate, nasal, liquid and glide. Regarding the place of articulation, consonants can be classified as bilabial, labiodental, dental, alveolar, palatal, velar, and glottal (p. 61).

Kelly (2000), Hancock (2003), Celce-Murcia, Brinton, Goodwin, and Griner (2010), and Carr (2013) have offered variations on the classification of English phonemes into consonants and vowels or the "segmental aspect of language" (Celce-Murcia et al, 2010, p. 41). Table 1 shows the lists of consonant sounds that these authors have created. Celce-Murcia et al. (2010) acknowledge that in North American English (NAE), /hw/ represents an "older and more conservative" pronunciation, and also state that in NAE, /hw/ and /w/ are possible (p. 53). Kelly (2000), Hancock (2003), and Carr (2013) use /j/, whereas Celce-Murcia, Brinton, Goodwin, and Griner (2010) use /y/. Moreover, Carr

(2013) uses /ɹ/ instead of /r/. From this table, it can be seen that the aforementioned authors coincide with all the consonant sounds that English has.

Table1. *Comparative inventories of consonants*

Inventories of consonants by different authors

Kelly (2000) p. 48	Hancock (2003) p.130	Celce-Murcia et al. (2010) p. 53	Carr (2013) p . 42
/p/	/p/	/p/	/p/
/b/	/b/	/b/	/b/
/t/	/t/	/t/	/t/
/d/	/d/	/d/	/d/
/k/	/k/	/g/	/k/
/g/	/g/	/k/	/g/
/tʃ/	/tʃ/	/v/	/v/
/dʒ/	/dʒ/	/f/	/f/
/f/	/f/	/Θ/	/Θ/
/v/	/v/	/ð/	/ð/
/Θ/	/Θ/	/s/	/s/
/ð/	/ð/	/z/	/z/
/s/	/s/	/ʃ/	/ʃ/
/z/	/z/	/ʒ/	/ʒ/
/ʃ/	/ʃ/	/h/	/h/
/ʒ/	/ʒ/	/tʃ/	/tʃ/
/h/	/h/	/dʒ/	/dʒ/
/m/	/m/	/m/	/m/
/n/	/n/	/n/	/n/
/ŋ/	/ŋ/	/ŋ/	/ŋ/
/l/	/l/	/l/	/l/
/r/	/r/	/r/	/ɹ/
/j/	/j/	/y/	/j/
/w/	/w/	/w/	/w/
		/hw/	

Regarding vowels, Carr (3013) states that there are two type: monophthongs and diphthongs (p. 24). When "the vowel quality (the acoustic effect created during the articulation of the vowel) remains more or less the constant," vowels are monophthongs. Diphthongs "entails some kind of change of position of the articulators during its production, and thus a change in the vowel quality produced. A diphthong is a vowel whose quality changes within the syllable" (p. 24). Concerning this topic, Celce-Murcia et al. (2010) state that "eleven of the fourteen stressed vowels of NAE are either simple vowels (vowels without an accompanying glide movement) or vowels with an adjacent glide (vowels accompanied by /y/ or /w/)" (p. 114). These authors define diphthongs as "vowels consisting of a vowel sound followed by a nonadjacent glide within the same syllable" (p. 114). Moreover, these authors state that "vowel sounds can be distinguished from each other by which part of the tongue is involved (front, central, back) and by how high the tongue is when the sound is produced (high, mid, low)" (p. 115).

Kelly (2000), Hancock (2003), Celce-Murcia et al. (2010), and Carr (2013) have categorized the English vowels differently; Table 2 shows a comparative inventory of their vowels. From these comparative inventories, it can be seen that Kelly (2000) has listed 12 vowels (p. 38) and eight diphthongs (p. 39). This author defines a diphthong as "a combination of vowel sounds … There is a glide (or movement of the tongue, lips, and jaw) from one pure vowel to another" (p. 34). Hancock (2003) does not make any differentiation between monophthongs and diphthongs (p.130), and only disagrees with Kelly (2000) about /ʊə/. Contrastively, Celce-Murcia et al. (2010) have listed 11 simple vowels and three diphthongs: /ay/, /aw/, and /ɔy/ in NAE (p. 114). They did not include /ə/ and its counterpart /ə^{r}/ in their inventory because they listed stressed vowels and

diphthongs, and schwa is one of the reduced vowels. Other reduced forms that NAE has are /I/, /i/, /o/, and /u/ (p. 131). These authors listed three diphthongs because "they consist of two nonadjacent sounds and involve a broad gliding movement from one point of articulation to the other" (p. 122). Table 2 shows these inventories.

Table 2.
Comparative inventories of vowels

Inventories of vowels by different authors			
Kelly (2000) p. 38	Hancock (2003) p.130	Celce-Murcia et al. (2010) p. 115	Carr (2013) p. 48 GA
/iː/	/iː/	/iy/	/iː/
/ɪ/	/ɪ/	/ɪ/	/ɪ/
/ʊ/	/ʊ/	/ʊ/	/ʊ/
/uː/	/uː/	/uw/	/uː/
/e/	/e/	/ɛ/	/ɛ/
/ə/	/ə/	-	-
/ɜː/	/ɜː/	-	/ɜ/
/ɔː/	/ɔː/	/ɔ/	/ɔː/
/æ/	/æ/	/æ/	/æ/
/ʌ/	/ʌ/	/ʌ/	/ʌ/
/ɑː/	/ɑː/	-	-
/ɒ/	/ɒ/	/ɑ/	/ɑ/
Diphthongs p. 39			Diphthongs p. 24
/ɪə/	/ɪə/	-	/ɪə/
/ʊə/	-	-	-
/eə/	/eə/	-	-
/eɪ/	/eɪ/	/ey/	/eɪ/
/əʊ/	/əʊ/	/ow/	/oʊ/
		Diphthongs	
/ɔɪ/	/ɔɪ/	/ɔy/	/ɔɪ/
/aɪ/	/aɪ/	/ay/	/aɪ/
/aʊ/	/aʊ/	/aw/	/aʊ/

Concerning Carr (2013), he has listed vowels from two accents: Received Pronunciation (RP), which is the British accent and related to social class and prestige, and General American (GA), which is related to a great part of the United States (p. 18); Table 2 only shows GA for geographical convenience and exposure. In his inventory, Carr (2013) does not list /ə/; however, he mentions it as a vowel "shorter of than the short vowels [/I/, /ʊ̆/, /ɛ/, /ʌ/, /æ/, and /ɑ/]…, and differs from those in that it may never occur in a stressed syllable" (p. 21). Carr (2013) states that /ɪə/, /ʊ̆ə/, and /ɛə/ "are all absent in GA" (p. 26). Consequently, this author recognizes six diphthongs in General American accent. This comparative vowel inventory of these authors shows that there is no consensus among them. Avery and Ehrlich (1992) consider /aw/, /ay/, and /oy/ "to complex vowel sounds because they consist of a vowel followed by a semi-vowel, either /y/ or /w/" (p. 34). They do not consider /iy/, /ey/, /ow/, and /uw/ as diphthongs "because there is less tongue movement with these vowels than with the diphthongs /ay/, /aw/, and /oy/" (p. 34). In the same way, Grant (2001) lists those three diphthongs. She states that "diphthongs are combinations of two vowel sounds. Your mouth moves and changes shape as you pronounce diphthongs" (p. 190). Distinctly, Roach (2009) defines diphthongs as "sounds which consist of a movement or glide from one vowel to another" (p. 17). This author lists eight diphthongs: /eɪ/, /aɪ/,/ɔɪ/, /ɪə/, /eə/, /ʊ̆ə/, /əʊ/, and /aʊ̆/. Similarly, Rogerson-Revell (2011) lists the same diphthongs (p. 78). As a conclusion, authors disagree about the English diphthongs. Some say that English has three, whereas other state that eight are the English diphthongs. For the purpose of this study, the eight-diphthong statement is considered the best because by definitions, diphthongs are one vowel that glides to another one. If the second sound is or is not close to a similar point of articulation, it does not change the fact that the two sounds are distinct. The only condition is to be in the same

syllable. By knowing how consonants and vowels function, EFL teachers can address pronunciation problems more easily.

The concept of syllable has an important role in pronunciation, which teachers must be aware of to teach word stress. Dalton and Seidlhoper (1994) state that the importance of the syllable as a language-unit is related to the history of writing: syllabaries are older than alphabets (p. 35). Syllable definitions fall into two groups: one focuses on the physical, and the other focuses on the mental processes. The physical definition states that the air leaves the lungs in puffs instead of a continuous stream; this explains why the syllable is intuitively sensed by speakers. Dalton and Seidlhoper (1994) also state that the concept of syllable is universal whereas the shape of it is not. In English, the syllable can take the following forms (C is for consonant, and V is for vowel), CVC, CV, VCC, CCV, VC, CCVC, CCVCC, and CCCVCCC. The problem is how to divide up polysyllabic words. The task becomes more difficult when the words are embedded in a speech or stream of sounds (p. 37). Accordingly, syllabication plays a relevant role in pronunciation because the primary stress falls on a syllable, and when the words have more than one syllable, some rules are necessary to place the stress correctly.

Word stress has some tendencies that EFL teachers should know about when teaching pronunciation. Carr (2013, p. 74) lists four general principles that generalize and systematize stress patterns.

1. The End-Based Principle states that stress is calculated by counting from the end of the word; in other words, the stress of a word will fall either on the last, penultimate, or the antepenultimate syllable. This fact reflects that stress patterns are trochaic, which is a stressed syllable followed by an unstressed syllable.

2. The Rhythmic Principle refers to the fact that English words can end with as many as four unstressed syllables; however, they cannot begin with more than one. This principle is related to the first one because the ideal rhythmic structure of English is the trochaic foot, which implies a secondary stress to achieve such desirable rhythm. For instance, the word *Japan* / dʒə 'pæn / has the stress on the last syllable; however, the derivational word *Japanese* / ˌdʒæ pə'niz / has a secondary stress on the third last syllable to create the trochee.

3. The Derivational Principle establishes that when derivational words occur, the secondary stress is going to occur where the primary stress falls in the deriving word. For example, the word *character* / 'kæ rɪk tər/ has the primary stress on the third last syllable; thus, the derived word *characteristic* / ˌkæ rɪk tə 'rɪs tɪk / has the secondary stress on the syllable that had the primary stress in the derived word.

4. The Stress Clash Avoidance Principle states that two stressed adjacent syllables are avoided. According to the derivational principle, the word *Japanese* should have the secondary stress on the penultimate syllable /pæ/. However, the Stress Clash Avoidance principle overrules and dictates that the secondary stress has to be on the antepenultimate syllable. Carr (2013) also advises that even though this fourth principle is strong and seems to be the tendency, some words do not follow this principle, for example *rerun* / rI 'rʌn / (p. 74). Hence, these four principles intend to explain and generalize pronunciation patterns.

Even though for stressing a word, “there no hard and fast rules” (Avery & Ehrlich, 1992, p. 67), some factors are essential to determine word stress placement. In general, Hancock (2003) states that “in words with two or more syllables, at least one syllable is weak (does not have stress)” (p. 22). Concerning weak syllables, this author also states that native English speaker very often use /ə/ and /I/ as weak vowel sounds (p. 22). On the

other hand, Carr (2013, p. 78) has identified four factors that affect stress placement: syntactic category of the word, historical prefixes of Latinate origin, spelling (words ending in double vowel letter will have the primary stress on them), and loanwords will often keep their stress pattern from the language that they were borrowed from. In detail, Carr (2013) has also divided the words into bisyllabic nouns, adjectives, adverbs, and verbs and polysyllabic nouns, adjectives and verbs to explain generalities about word stress (p. 76). Regarding bisyllabic nouns, this author states that these words have the primary stress on the second last syllable, for example, *lemon* and *market*. However, words that have been borrowed from other languages usually have the main stress on the last syllable, as in *balloon* and *bazaar*. Concerning bisyllabic adjectives, these words have the main stress on the second last syllable; nonetheless, there are some exceptions, such as *intense* and *precise*, that have the main stress on the last syllable. Carr (2013) claims that historical prefixes come from Latin and French (p. 77). In bisyllabic adverbs, the trochaic pattern is the constant, for example, *slowly* and *quickly*. However, regarding verbs, the trochaic foot is less evident. Many bisyllabic verbs have the primary stress on the last syllable because these words were borrowed from Latin and French. In these languages, the words had prefixes, and the dominant tendency is to avoid stressing those historical prefixes. The words *deny* and *produce* are examples of this fact.

Polysyllabic nouns have a trochaic pattern. According to Carr (2013), in words with more than two syllables, the primary stress falls on the third last syllable, as in *academy* and *camera*; nonetheless, exceptions are abundant, which have the stress on the last syllable; these words mainly come from French. Moreover, in some words, the stress falls on a consonant cluster after the penultimate vowel, such as in *apartment* and *disaster*. Some

nouns with three or more syllables ending in *–ics* have penultimate stress, as in *logistics*. Lastly, some loanwords ending in a vowel sound usually have penultimate stress, like *banana* and *potato*. In general, polysyllabic adjectives show a basic trochaic pattern with the stress on the antepenultimate syllable, as in *intelligent*. Some adjectives with a consonant cluster after the penultimate vowel have the stress on the penultimate syllable; for example, *de**pen**dent* and *ob**jec**tive*. Words which have an 'rC (c is for consonant) are included in this group, as in *maternal*. In polysyllabic adjectives that end in –ate, the stress falls on the antepenultimate syllable, as in *elaborate*. On the other hand, polysyllabic verbs do not follow the trochaic basic pattern; verbs with three or more syllables have final word stress, as in *entertain* and *intervene*. Verbs ending in –ate, the stress falls on the third last syllable, as in investigate. Both polysyllabic verbs and polysyllabic adjectives ending in –ate have the same antepenultimate stress pattern (p. 77). To this topic, Hancock (2003) states that "the stress stays in the same place when we make longer words from […] two-syllable nouns, adjectives and verbs. For example, […] in both *depart* and *departure*, the stress is on the syllable *part*" (p. 64). Therefore, stress patterns are usually predicted.

The morphological structure of a word might affect word stress. According to Carr (2013), both prefixes and suffixes sometimes alter the stress patterns. Hence, monosyllabic prefixes have secondary stress, as in ***co**edit*, ***de**regulation*, ***dis**appear*, ***ex**-boss*, ***in**correct*, ***mal**adjusted*, ***mis**spelled*, ***pre**-pay*, ***pro**-life*, ***re**appear*, ***sub**-atomic*, ***trans**-Atlantic*, ***un**fair*. On the other hand, bisyllabic prefixes form a trochaic foot; consequently, they will take secondary stress, as in ***anti**bacterial*. There are some cases where these they will have primary stress, such as in ***anti**matter* or in ***mega**byte*. The previous prefixes come from Latin; some noun-verb pairs make use of this feature to define the primary stress: the verb

is stressed on the final syllable, and the noun is stressed on the Latinate prefix, as in *re**search*** (verb) and ***re**search* (noun). Similarly, Hancock (2003) states that "some words are nouns and verbs. For example, *record* is a noun if you put stress on the first syllable, and a verb if you put stress on the second syllable" (p. 64). Other pairs simply do not change, as in debate. Concerning this fact, Avery, and Ehrlich (1992) state that "more than 60 per cent of all [two-syllables] English verbs are stressed on the second syllable" (67). To this subject matter, Lewis (1997) adds that some grammatical categories, for example nouns, take more meaning than others (p. 23). Consequently, morphology is determinant in pronunciation.

Suffixes also play an important role concerning word stress because the addition of some suffixes changes the primary stress in a word. Rogerson-Revell (2011) states that "affixes can have one of the three possible effects on word stress: the affix is stressed, the affix has no effect, and the affix is not stressed but the stress on the stem moves" (p. 144). Suffixes are divided into inflectional and derivational. On the one hand, inflectional suffixes create a different form of the word, for instance, *obscure* and *obscuring*. These suffixes are not stressed; consequently, they will not affect word stress (Carr, 2013, p. 79). On the other hand, derivational suffixes create a new word, for example, dark and darkness. These two words are different from each other, and sometimes this addition changes the word stress; this is called stress-neutral and stress-shifting suffixes. Carr (2013) states that there are two kinds of these suffixes: those on which the primary stress falls, and those which switch the primary stress (p. 81). Thus, the suffixes -ee, -eer, and -ese are examples of suffixes which will receive the primary stress. For instance, in the word mountaineer, the Rhythmic Principle and the Stress Clash Avoidance Principle are applied to the stress

pattern on this word. In general, when two principles are in conflict, the Stress Clash Avoidance Principle predominates. For example, in the word *employee*, the Rhythmic Principle and the Derivational Principle are in conflict. Thus, the Stress Clash Avoidance Principle establishes its supremacy, and the word stress falls as this / ˌɛm plɔɪ 'i /. This author illustrates this rule with the word *employee*; however, it is important to highlight that this word can also be pronounced / ˌɛm 'plɔɪ i/. Since English is a Germanic language, all Germanic suffixes are stress free; they are neutral. For instance, the word stress in bright does not change when -ly is added, as with brightly. Similarly, this happens with the word *green* when the derivational words *greener, greenest,* and *greenish* are produced. Likewise, the suffixes *-ful*, *-less*, and *-y* will not change the primary stress of the word to which these suffixes can be added (p. 80). In brief, inflectional and Germanic derivational suffixes will not affect word stress.

On the other hand, the borrowed suffix *-ette* is attached to some words, and it changes the pronunciation, for example, kitchenette and sermonette. However, there are some cases when it is difficult to say if the suffix *-ette* is or not a suffix, as in etiquette and gazette. Related to suffixes that change the primary stress position, Carr (2013) has listed *-ity* and *-ic*, as in personal / personality and atom / atomic. Other suffixes that change the primary stress position are *–ous* (advantage / advantageous) and *-ious* (injure / injurious). This same author highlights that when the primary stress is moved due to the addition of the aforementioned suffixes, the pronunciation of the affected syllable changes. Thus, the final schwa in *person**a**l* is changed when the suffix -ity is added, and it becomes /æ/, *person**a**lity*. Similarly, some consonants are affected as well due to this addition. In the word opaque, the /k/ sound changes when the suffix *-ity* is added, and it becomes /s/ in

opacity. Another example is when the /t/ in *president* changes to /s/ in *presidency*. It is worth mentioning that the more variation due to stress patterns and vowel and consonant realization, the less evident that the base and the affixed forms are related. By knowing these facts, pronunciation may become more predictable.

Once the stressed syllable is detected, some other features also happen. Kelly (2000) indicates that loudness, pitch change, and a longer syllable accompany the primary stress syllable (p. 67); Derwing and Munro (2015) agree on these characteristics as well (p. 59). Consequently, an unstressed syllable will lack these three features. Related to the primary stress, Grant et al. (2014) add that the most salient features are length and clarity (p.16). Likewise, these authors state that "misplacing stress can lead to misunderstandings and not just within words, but across words' boundaries" (p. 16). They exemplify this fact with the word *history*; if the main stress is placed on *to*, the word could be understood as ***his story***. Hence, the correct pronunciation of each word affects the word itself and the surrounding ones.

Consecutively, at least three different kinds of stress can be clearly identified. Kelly (2000) also agrees with many authors on the fact that three levels of stress can be distinguished; they are primary stress, secondary stress, and unstress (p. 69). Kelly states that "schwa is by nature an unstressed sound" (p. 68). This author also indicates that if a schwa is stressed, properties are changed, and a new phoneme is produced (p. 68). Interestingly, schwa can be represented by "a" (arise), "e" (vowel), "i" (experiment), "o" (tomorrow), and "u" (difficult). Likewise, schwa can be represented by combinations of letters such as in "ia" (spatial), "io" (session), and "ou" (fictitious) (p. 68). This fact pointed out by Kelly (2000) is in accordance with Carr (2013), who states that historical

reasons are responsible for the complex and arbitrary relationship between spelling and pronunciation in English (p. 126). Thus, being aware of these three kinds of stress may greatly improve pronunciation.

Pronunciation teaching has different levels that are important to address. Grant et al. (2014) have listed four. The first level refers to motor or physical; descriptions of the sounds are necessary for the students to produce them. The second level is the perceptual; learners have to be perceptually trained to identify sounds that students do not have in their native tongue and are in English. The cognitive level is the third; training, exposure, and practice are fundamental to form perceptual categories on which learners base their pronunciation. Pronunciation happens in the mouth as well as in the brain. The last level is psycho-social; the learner's attitude to pronunciation change is important because the learner needs to be intelligible (p. 28). By addressing these levels, pronunciation can change for better.

Concerning pronunciation teaching, two aspects to be kept in mind are comprehensibility and intelligibility. In other words, the speaker has to pronounce clearly in order for the listener to understand the message. According to Grant et al. (2014), comprehensibility and intelligibility are related to communicative success. These authors support the idea that language learners want and need to be understood; consequently, teachers are supposed to help students to achieve a comfortable intelligibility (p. 42). Similarly, these researchers affirm that suprasegmental training leads to improved comprehensibility and fluency (p. 41). Moreover, Derwing and Munro (2015) state that "assessing and teaching pronunciation requires a reasonable good familiarity with the sound inventory of the language being taught, and the associated phonetic symbols" (p.

114). On the other hand, Grant et al. (2014) state that even though we do not have a complete understanding of the most effective techniques to teach pronunciation (p. 42), there is a relationship between perception and production. Indeed, these authors advise that the teaching of pronunciation should focus on teaching perception (p. 46), giving explicit corrective feedback (p. 47), choosing the right focus to achieve intelligibility (48) because class time is short, using authentic language (p. 50), making judicious use of technology for individual instruction (p. 51), and avoiding fossilization to happen (p. 51). In relation to this topic, Brown (2007) adds that native language, age, exposure, innate phonetic ability, identity and language ego, and motivation for good pronunciation may affect pronunciation (p. 340). Consequently, ESL instructors must be aware of the nature of the pronunciation errors to correct them properly. Derwing and Munro (2015) state that "a clear understanding of the nature of L2 articulations provide instructors with the tools they need to explain how to modify segmental productions" (p. 114). In short, the more teaching on pronunciation, the better the results.

Finally, pronunciation errors have different origins; they could derive from segmental or suprasegmental features. Even L1 may affect correct pronunciation. Derwing and Munro (2015) define a pronunciation error as the production of an utterance, but as a result of control of segmentals and suprasegmentals, the speaker produces something else (p. 57). They have classified pronunciation errors into two categories: segmental and prosodic ones. Regarding segmental errors, these authors have identified four; they are insertion (including a segment not present in the word), deletion (excluding a segment that is present in the word), substitution (replacing a segment in the word by another phoneme), and distortion (producing a segment that noticeably is not the correct one but does not

change the sound: short aspiration, for example /k^h/ instead of /k/). Segmental errors affect the word and beyond the word (p. 58). Suprasegmental errors, in the form of word stress, occur when the speaker does not stress the correct syllable; this error leads to unintelligibility. Similarly, Goodwin (2014) points out that incorrect word stress is one of the causes of lack of intelligibility (p.144). On the other hand, Derwing and Munro (2015) mention errors at sentence level such as intonation and rhythm, but these errors are out of the scope of this literature review. These authors have presented a Contrastive Analysis Hypothesis in an attempt to the possible origin of pronunciation errors in L2 that may have their origin in L1; they have identified four error types. The first one is positive transfer (L1 and L2 have an identical phoneme), under-differentiation (L1 treats two sounds as allophones of a phoneme, but in L2, the sounds are distinct phonemes), new item (L1 does not have the sound), and split (one sound in L1 is two in L2) (p. 64). To sum up, pronunciation errors can occur at two levels, segmentals or suprasegmetals; moreover, L1 might induce L2 learners to make pronunciation errors.

In all, this literature review has gone through all the different topics related to oral production of vocabulary, from phonemes to syllables to word stress. In fact, Wilkins, as cited in Thornbury (2002), states that "without grammar very little can be conveyed, without vocabulary nothing can be conveyed" (p. 13). This quotation reveals that vocabulary, and its correct pronunciation, is a basic feature for effective oral communication.

C. Methodology

1. Participants

The participants in this research study were five female chemistry students at UCR. They were in the second or third year of the major, and one participant was finishing her major. According to the needs analysis of this particular population, these students seemed to have an intermediate level of English, based on the locally-designed diagnostic exam. These students took an ESP course designed to improve their English. They were required to attend classes once a week for three hours on Wednesdays. The main goal of the participants was to develop oral skills to perform tasks related to the field of chemistry such as asking questions, describing chemical processes, and giving information about chemistry.

2. Instruments

The data were collected by means of audio recordings of each individual student reading aloud lists of chemistry-related words, derived from each of the three units taught. The words in each list were selected after completing each unit of study in the Chemming Words ESP course. Thus, the first list had 25 words; the second list had 35 words, and the third list had 20 words. Consequently, 80 words were selected as part of this research (see Appendix N). At the end of each unit, the students had an assessment session. The day of the assessment, the students were asked to read the words aloud in order to record their pronunciation; thus, 480 words were recorded, and those recordings were the source of data.

The instrument to analyze the data has five parts (see Appendix O). The first part concerns word stress. It evaluates whether or not the stress was correctly placed. The second part deals with vowels; this part evaluates possible vowel changes. The third part relates to possible diphthong changes. The fourth part assesses if the consonants were or not pronounced correctly. The last part is about insertion or deletion of sounds. Furthermore, another instrument was necessary to analyze the words spelled with the letter "o" (see Appendix P). This instrument evaluates the production of the letter "o". Since the letter "o" has several realizations, this instrument was intended to collect the changes that participants made when they pronounced the words; nine changes are given.

3. Procedure

Before the collection of data, the participants took classes. The investigation was conducted in an ESP environment. This means that the students used the research vocabulary in class by performing tasks. Students rehearsed their performances, and thus, used the research words; during this time, students received pronunciation assistance as well as any other necessary help. After performing the main task, the words that were still mispronounced were highlighted on the board to correct the pronunciation. In the following class, students reviewed the key words from the last class as a form to open the class session. Both pronunciation and meaning were reviewed. The vocabulary was presented in different forms; for instance, students saw a picture to recall a concept. They said the target word. If they could not recall the word, the students saw a new slide with the picture and the word. Then, they pronounced the word. Sometimes, one student read the question: how do you pronounce this word? from a slideshow for another student to answer. Then, the second student pronounced the target word. Another activity to review

key vocabulary was to read a definition of a target word. By doing this, students could recall the intended word. If not, the word was provided for them to pronounce. In these vocabulary reviewing activities, if a mistake was made, the instructor corrected the mistake at the moment. Therefore, the learners were exposed to the words through videos, speaking tasks, and oral drilling exercises.

The use of the International Phonetic Alphabet (IPA) was helpful for the students to visualize the sounds. By using the symbols of this phonetic alphabet, the students could see where they were mispronouncing a particular word. In addition, the phonetic symbols helped the students to associate the written form to the oral one, especially for words that are very similar in spelling and meaning. For instance, the words *alkane*, *alkene*, and *alkine* (or *alkyne*) were transcribed phonetically for the students to see how the suffixes in these words are pronounced.

Students became aware of the sounds that the letter "o" stands for. Students realized that the letter "o" has four realizations in English: /ɑ/, as in br**o**nze /br**ɑ**nz/, /ɔ/, as in f**o**rmula /ˈf**ɔ**rmyələ/, /oʊ/, as in ket**o** /ˈkit**oʊ**/, and /ə/, as in p**o**lonium /p**ə**ˈloʊniəm/. This instruction helped them improve their pronunciation. Similarly, the instructor also highlighted the schwa. Students were told that this sound is very frequent in English words, is the most neutral sound in English, and is usually in syllables that are not stressed. Examples of this sound are *c**o**llide* /k**ə**ˈlaɪd/, *coval**e**nt* /koʊˈveɪl**ə**nt/, *alc**o**hol* /ˈælk**ə**ˌhɔl, -ˌhɒl/, *s**a**pon**i**fy* /s**ə**ˈpɑn**ə**ˌfaɪ/, and *is**o**tropic* /ˌaɪs**ə**ˈtrɑpɪk, -ˈtroʊpɪk/. Therefore, students rehearsed, used, and reviewed the words under the scope widely.

Syllable recognition is essential to stress a word correctly, and therefore, to have a correct pronunciation. Some words were used to exemplify basic stress patterns. For

instance, the words *cation*, *enzyme*, and *lattice* are examples of two-syllable words which have stress on the penultimate syllable. However, the word collide, which is an exception to this rule, was also provided. This way, students had both the rule and the exceptions. Moreover, students were instructed that a single "e" at the end of English words is silent most of the times; this fact helped them recognize syllables more easily and more accurately. For example, words such as phosphate and volume do not have three syllables; they have two. This fact helps to recognize syllables correctly. In this same topic, the word ***pro****panoic*, ***te****trachloride*, and ***stoi****chiometry* are multisyllabic words that have the secondary stress on the first syllable of the words. After this syllable, an unstressed one follows, and the main-stress syllable takes place then. These words exemplify the principle that English words do not start with more than two unstressed syllables. On the other hand, the word phosphorylation derives from the word phosphate. The root word has the main stress on the main syllable, whereas the derivational word has the main stress on the penultimate syllable. However, the secondary stress falls on the syllable whose main stress is in the root word. This example illustrates the derivational principle, whose can also be seen in the derivational word *crystallography*, which comes from *crystal*. Another principle regarding word stress is exemplified with the words *anisotropic*, *isotropic*, and *phosphorylation*. Both main and secondary stress are not adjacent. When it is possible, there should be, at least, one unstressed syllable between both stresses.

At the end of each unit, students were asked to record a list of selected words that they had practiced in class. After the students recorded the words, the analysis took place. The researcher was the only rater in the study. The researcher listened to the recordings to evaluate whether or not the word was correctly pronounced. A list of pronunciation mistakes was made for each word. Each mistake was granted one point in order to quantify

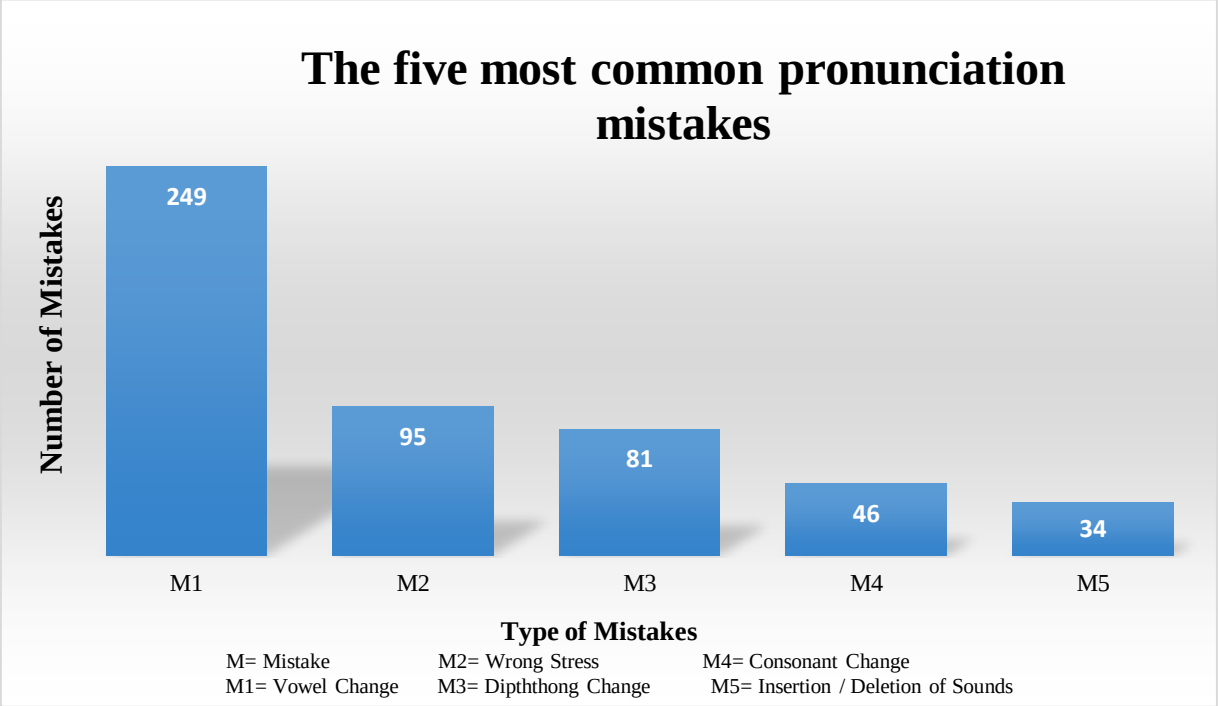
the total number of mistakes that the students made when they pronounced each word. As a result, a pattern appeared. Five common pronunciation categories came to light.

The first one was vowel change. In other words, the participant changed the correct vowel sound and produced another vowel or a diphthong that was not the correct one. Regarding the word ***a**nti**o**xidant,* one participant made two mistakes concerning vowel change; the participant said /ɑ/ instead of /æ/ and /o/ instead of /ɑ/ respectively. Since each mistake is given a point, in this case, the word was assigned two points. The second category involves word stress. This means that the participant changed the main stress of the word and placed it on another syllable. For example, the word *tetrachlo**ri**de* was pronounced with the main stress on the syllable *ri* (raɪd) instead of *chlo* (klɔ). As a consequence, the word received a point to quantify this particular mistake. The third category is diphthong change. This means that the participant replaced the diphthong with a different vowel sound or another diphthong. For instance, the word *ur**a**ni**u**m* was pronounced with /ɑ/ instead of /eɪ/, /ʊ/ instead of /iə/. Another salient mistake was consonant change. This change consisted of replacing the correct consonant with another that was not the correct one. For example, the word *me**th**ionine* was pronounced with /t/ instead of /ɵ/. The last mistake was insertion or deletion of a sound; they were vowels or consonants as well. For instance, in the word *antioxidan**t***, the participant eliminated the final /t/. Once the data was processed, the points assigned to each category were added to obtain general results, which are the ones analyzed in the next section.

D. Results and Discussion

The research question that guided this study was what the most common pronunciation mistakes were concerning chemistry-related words that a group of chemistry students made. The sample consisted of 80 words. The first finding answers the research question straightforwardly. This study has found five main problems regarding chemistry-related words: vowel change, wrong stress, diphthong change, consonant change, and insertion or deletion of sounds. Figure 10 illustrates this result, and it also answers the first subsequent question, which is how those pronunciation mistakes are ranked.

Figure 10. The five most common pronunciation mistakes



Vowel change is the mistake that participants made the most. Out of the 80 words, 62 words correspond to this type of mistake. The word *anisotropic* /ænˌaɪsəˈtrɑpɪk/ or /ænˌaɪsəˈtroʊpɪk/ was the one which scored the most mistake-pronunciation points under

this category. The most recurrent mistakes were /ə/ instead of /æ/ in ***a****nisotropic* /ənˌaɪsəˈtrɑpɪk/, /o/ instead of /ə/ in *anis****o****tropic* /ænˌaɪsoˈtrɑpɪk/, /o/ instead of /ɑ/ or /oʊ/ in *anisotr****o****pic* /ænˌaɪsəˈtropɪk/. The second word that scored the highest mistake-pronunciation punctuation was *propanoic* /ˌproʊpəˈnoʊɪk/. This word is spelled with the letter "o" twice. In both cases, the correct sound is /oʊ̃/, and 100% of the participants said /o/ instead (/ˌpropəˈnoɪk/). The third word in this category is *antioxidant* /ˌæntiˈɑksɪdənt/ or /ˌæntaɪˈɑksɪdənt/. In this word, the diagraph was changed to a Latin a, and the sound that the letter "o" stands for was changed to /o/. Thus, the word was pronounced /ɑnti'oksIdənt/.

These three words exemplify what Derwing and Munro (2015) state; these vowel changes belong to the category of phoneme substitution (p. 58). Moreover, these three words share a common feature; they have the letter "o" in their spelling, and the participants mispronounced the phonemes that this letter represents. According to the authors cited previously, a possible origin of this mistake is L1; they state that a "new item" (p. 64) happens when the L1 does not have the intended phoneme in its phonological system. Since the speaker may not know this new phonetic item, the speaker will use one that he or she is familiar with in order to pronounce the word.

Regarding the second common mistake, this investigation has found that word stress also affects correct pronunciation. In this regard, out of the 80 words, 44 words were affected by stressing the words incorrectly. The words *cation* /ˈkætaɪən/ or /ˈkætaɪɑn/ and *disulfide* /daɪˈsʌlfaɪd, -fɪd/ were the most affected; all the participants changed the main stress position, from ***ca***tion /ˈ**kæ**taɪən/ to ca***tion*** /kæˈ**taɪ**ən/, and from di***sul***fide to disul***fide*** /daɪsʌlˈfaɪd/ or ***di***sulfide /ˈdaɪsʌlfaɪd/. Similarly, 80 % of the participants changed the stress

in the words *enzyme* /ˈɛnzaɪm/, *enol* /ˈinɔl, -nɑl/, *nitrate* /ˈnaɪtreɪt, -trɪt/, and *tetrachloride* /ˌtɛtrəˈklɔraɪd, -ɪd, -ˈkloʊr-/. In the case of *enzyme* /ˈɛnzaɪm/, the stress was moved to *en**zy**me* /ɛnˈzaɪm/. The word *enol* /ˈinɔl, -nɑl/ was pronounced with the main stress on the second syllable instead of the first one. The stress in the word *nitrate* /ˈnaɪtreɪt/ was moved to the second syllable (/naɪˈtreɪt/). Regarding the word *tetrachloride* /ˌtɛtrəˈklɔraɪd, -ɪd, -ˈkloʊr-/, 60 % of the participants moved the main stress to the last syllable (tetrachlo**ride** /ˌtɛtrəklɔˈraɪd/), and 20 % of them moved the main stress to the second syllable (te**tra**chloride /ˌtɛˈtrɑklɔraɪd/). Likewise, 60% of the participants mispronounced words such as *alkane* /ˈælkeɪn/ by changing the stress to *al**ka**ne* /ælˈkeɪn/, *alkene* /ˈælkin/ by moving the stress to *al**ke**ne* /ælˈkin/. Similarly, in the following examples, the stress was moved, and other pronunciation problems took place; the phonetic transcriptions make evident those mispronunciations. Hence, 60% of the participants mispronounced words such as *anhydrase* /ənˈhaɪdreɪs, -dreɪz/ by changing the stress to ***an**hydrase* /ˈɛnɪdreis/ or *anhy**drase*** /ɛnəˈdrais/, *coalesce* /ˌkoʊəˈlɛs/ by changing the stress to *co**a**lesce* /kəˈ**ɑ**lɪs/ or **co**alese /ˈ**ko**əlɪs/ or /ˈ**koʊ**lɛs/, *dioxide* /daɪˈɑksaɪd, -sɪd/ by moving the stress to ***di**oxide* /ˈ**daɪ**ɑksaɪd/ *or dio**xide*** /daɪɑkˈ**saɪd**/, *electron* /ɪˈlɛk trɑn, -trən/ by changing the stress to ***e**lectron* /ˈ**ɛ**ləktrən, *methane* /ˈmɛθeɪn/ by moving the stress to *me**thane*** /mɛˈ**θeɪn**/, *methionine* /mɛˈθaɪənin, -nɪn/ by *changing the stress to **me**thionine* /ˈ**mɛ**tɪənɪn/, *methi**o**nine* /mɛθɪˈ**o**nɪn/, or *methio**nine*** /mɛθɪəˈ**nɪn**/, and s*toichiometry* /ˌstɔɪ kiˈɑmɪtri/ by moving the stress to ***stoi**chiometry* /ˈ**stoɪ**kɪomɛtri/ or s*toichio**me**try* /stɛkɪəˈ**mɛ**trɪk/ or /stɛkɪəˈ**mɛ**mətri/.

Concerning stress changes, Carr (2013) has stated that bisyllabic nouns such as cation /ˈkætaɪən/, *enzyme* /ˈɛnzaɪm/, *eno*l /ˈinɔl, -nɑl/, *nitrate*/ˈnaɪtreɪt, -trɪt/, alkane /ˈælkeɪn/, alkene /ˈælkin/, and *methane* /ˈmɛθeɪn/ have the main stress on the first syllable

(p. 76). This same author has stated that in general terms, polysyllabic nouns, adjectives, and verbs have the main stress on the antepenultimate syllable (p. 77); words like methionine /mɛˈθaɪənin, -nɪn/ and stoichiometry /ˌstɔɪkiˈɑmɪtri/ illustrate this point. However this author acknowledges that some exceptions are possible, for example, *anhydrase* /ənˈhaɪdreɪs, -dreɪz/, *coalesce* /ˌkoʊəˈlɛs/, and *electron* /ɪˈlɛk trɑn, -trən/. Moreover, Carr (2013) has stated that prefixes do not affect word stress (p. 83). Hence, the mispronunciation of ***di****sulfide* /ˈdaɪsʌlfaɪd/, ***di****oxide* /ˈ**daɪ**ɑksaɪd/, and ***tetra****chloride* /ˌtɛˈtrɑklɔraɪd/, as was found in this research, is not possible because the prefixes *di* and *tetra* do not receive the main stress. Regarding the word *disulfide* /daɪˈsʌlfaɪd/, 100 % of the participants moved the main stress to ***di****sulfide* /ˈ**daɪ**ɑksaɪd/ or *disul****fide*** /daɪsʌlˈ**faɪd**/. On the one hand, *di* cannot receive the main stress because prefixes are not stressed (Carr, 2013, p. 83). On the other hand, *-fide* cannot be stressed because of Carr's (2013) rhythmic principle: "English words cannot begin with more than one unstressed syllable" (p. 74).

Syllable stress change generates two mistakes at the same time: the change of the stressed syllable itself and vowel change; this fact is related to the trochaic principle of English pronunciation that Carr (2013) has formulated. An example is the word *cation* /ˈkætaɪən/. When the main stress is moved to the last syllable, the /æ/ is changed to /ə/ (/kəˈ**taɪ**ən/.). This change happens simultaneously because the energy to pronounce /æ/ is reduced in order to stress /aɪ/ in /kəˈt**aɪ**ən/. This change contradicts Carr (2013) and Kelly (2000), who state that most bisyllabic nouns have the primary stress on the first syllable.

Diphthong change is the third most common mistake. Concerning this topic, out of the 80 words, 41 words have diphthongs (see Appendix Q). The major problems were deletion or substitution of phonemes. The words *anhydrase* /ənˈhaɪdreɪs, -dreɪz/ and

disulfide /daɪˈsʌlfaɪd, -fɪd/ were problematic because the participants mispronounced the diphthongs that these two words have. The word *anhydrase* /ənˈhaɪdreɪs, -dreɪz/ has two diphthongs: /aɪ/ and /eɪ/ in the utterance order. 100% of the participants made a mistake regarding these diphthongs; some of them are inversion of the diphthongs, substitution of /aɪ/ for /ɑ/ or /ɪ/, and substitution of /eɪ/ for /ɑ/. In these two words, only one letter stands for the two different sounds that form the diphthong; that might have confused the participants. For example, 100% of the participants pronounced the prefix *di* in *disulfide* as /di/ instead of /daɪ/. Other mispronounced words were *alkali* /ˈælkəlaɪ/ and *methionine* /mɛˈθaɪəˌnin, -nɪn/. The diphthong in the word *alkali* was changed to /i/ 100% of the time. This same change also happened in the word *methionine*; /aɪ/ was changed to /i/ by all the participants. Similarly, the words *antimony* /ˈæntəˌmoʊni/, *curium* /ˈkyʊəriəm/, *nitrate* /noun ˈnaɪ treɪt, -trɪt; verb ˈnaɪ treɪt/, and *trygliceride* /traɪˈglɪsəraɪd/ were mispronounced 80% of time. Concerning the word *antimony*, /oʊ/ was replaced by /o/. In the word *curium*, /yʊə/ was pronounced /yʊ/. The words *nitrate* and *trygliceride* represent a double challenge since they have two diphthongs. In *nitrate* /noun ˈnaɪ treɪt, -trɪt; verb ˈnaɪ treɪt/, /aɪ/ was changed to /ɪ/; however, the diphthong /eɪ/ was correctly pronounced. About the word *trygliceride* /traɪˈglɪsəraɪd/, the first diphthong was changed to /i/; the second diphthong was correctly pronounced. These mistakes reveal that the participants lack some of the knowledge that Celce-Murcia et al. (2010), Goodwin (2014), and Kelly (2000) have previously stated about production of the sounds (place and manner of articulation), distinction between a vowel and a diphthong, and possible English diphthongs. Furthermore, the replacement of the diphthongs by a vowel is in accordance with Derwing and Munro (2015), who have stated that “substitution” is one of the pronunciation errors.

The fourth pronunciation mistake concerns consonant change. The word *bismuth* /ˈbɪzməθ/ represented a pronunciation problem for 100 % of the participants: the /z/ was changed to /s/, and the /ə/ was changed to /t/. Therefore, the word underwent two consonant changes. Other words with similar problems were *polymerize* /pəˈlɪməˌraɪz, ˈpɑləmə-/ and *bronze* /brɑnz/; in both cases, 100% of the participants pronounced /s/ instead of /z/. *Methionine* /mɛˈθaɪəˌnin, -nɪn/ was another pronunciation challenge in terms of consonant pronunciation; all the participants replaced /ə/ with /t/. Similarly, 60% of the participants mispronounced the words *lutetium* /luˈtiʃiəm/ and *oxidizing* /ˈɑksɪˌdaɪzɪŋ/. About the word lutetium, /ʃ/ was replaced by /n/, /y/, and /t/. On the other hand, in the word *oxidizing*, /z/ was replaced by /s/. Consonant pronunciation mistakes are related to what Celce-Murcia et al. (2010), Goodwin (2014), and Kelly (2000) have stated about place and manner of articulation of the English consonants. The origin of the consonant pronunciation mistakes made by the participants coincide with one of the four pronunciation errors that Derwing and Munro (2015) have stated; “substitution” is the most salient mistake once again.

The last category was insertion or deletion of sounds. Regarding the latter, in the word *uranium* /yʊˈreɪniəm/, /y/ was deleted; thus, 60% of the times, the word was initially pronounced /ʊ'reiniəm/ instead of /yʊ'reiniəm/. Although this problem may be considered as a vowel one, for the purpose of this study, this problem was considered as a sound deletion: the /ʊ/ was there; the /y/ was missing. This finding agrees with Derwing and Munro (2015) since deletion (exclusion of a segment that is part of the word) is one of the possible pronunciation mistakes that these authors mention. On the other hand, 5% of the words under study did not represent a pronunciation problem for the participants. The

words *collide* /kəˈlaɪd/, *compound* /noun ˈkɑm paʊnd/, *process* /ˈprɑs ɛs/, and *silicon* /ˈsɪlɪkən, -kɑn/ were pronounced flawlessly.

While carrying out this research, the investigator noticed that a great number of words were spelled with the letter "o". This led to scrutinizing the selected words to effectively confirm the initial observation. Therefore, the researcher found that 45 words out of 80, which is 56.25% of the words under study, have the letter "o" in their spelling (see Appendix R). This fact is important to highlight because this letter has several realizations; the phonemic representations of those sounds are /oʊ/, /ɑ/, /ə/, and /ɔ/. Moreover, this fact originated the second subsequent research question because English learners may confuse those sounds or hesitate when pronouncing a word with "o", especially L1 Spanish speakers, because has only one realization of the letter "o", which is /o/. However, the letter "o" has four possible sound realizations in English. Examples of chemistry-related words whose spelling has the letter "o" and its corresponding pronunciation are shown in Table 3.

Table 3.
Examples of chemistry-related words with the letter "o" and its phonemic realizations

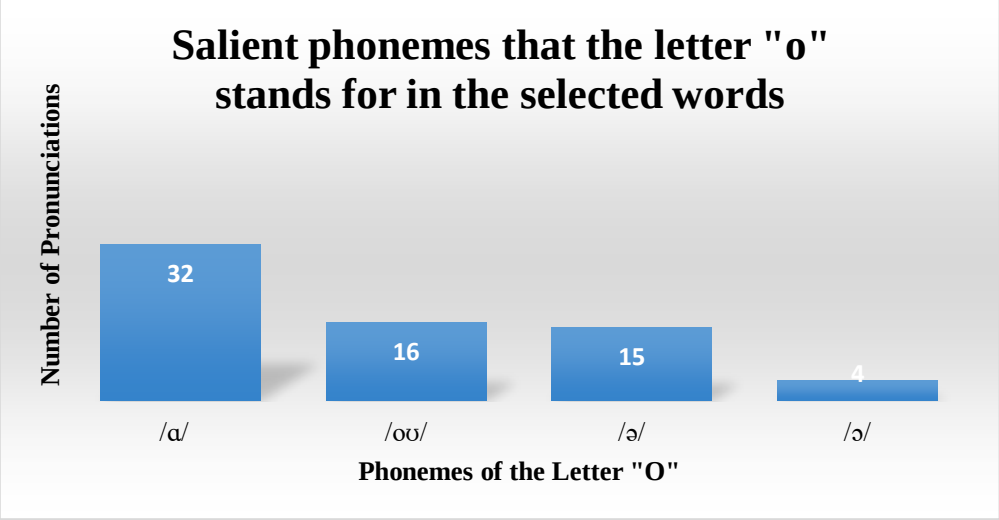
/ɑ/	/oʊ/	/ə/*	/ɔ/
bond	coalesce	collide	formula
bronze	covalent	isotropic	
copper	keto	polonium	
molecule	polar		
solid			
saponify			

*/ə/ is a reduction of the full version /ɑ/; it is not orthographic.

Since both English and Spanish have the letter “o” in their respective spelling systems, a Spanish speaker might pronounce this vowel incorrectly. In this research, the participants had to face the fact that when they saw a word with the letter “o”, they were supposed to produce a sound different from the one they are accustomed to. Hence, the speakers had to select one out of four possible sounds. This is a case of what Avery and Ehrlich (1992) mean when they state that one letter can represent different sounds (p. 3), and the mispronunciation of this sounds agrees with Derwing and Munro (2015), who have stated that “substitution” is one out of four pronunciation mistakes (p. 58). Similarly, these authors have also stated that pronunciation errors in the L2 might come from L1; a “new item” is when the L1 does not have the sounds that the L2 requires (p. 64). Therefore, the speaker uses what is known to him or her.

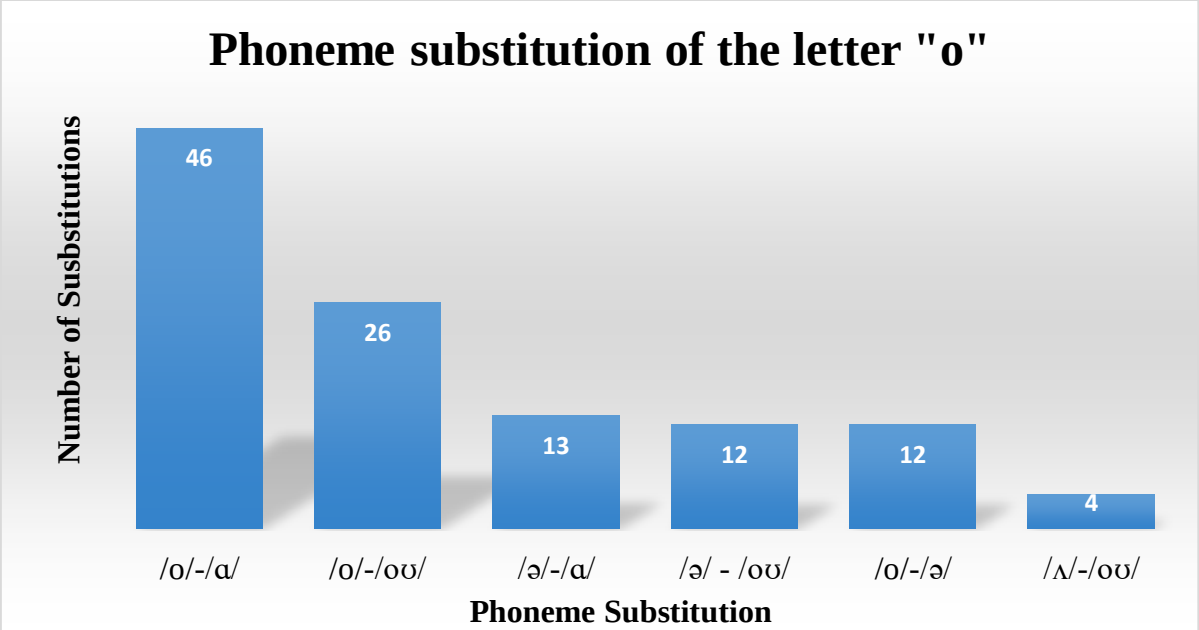
The following results answer the research questions that were designed for the second phase of this investigation. Hence, the second subsequent research question intends to find out what the pronunciation changes concerning the letter “o” are. First of all, Figure 11 shows that the majority of the words whose spelling contains the letter “o” are pronounced /ɑ/; /oʊ/ occupies the second place, /ə/ is in third place, and /ɔ/ is in the fourth position.

Figure 11. Salient phonemes that the letter “o” stands for in the selected words



This investigation found that the participants made substitutions when they were reading the chemistry-related words whose spelling has the letter “o”. Thus, Figure 12 shows six common incorrect substitutions.

Figure 12. Phoneme substitution when pronouncing words with the letter “o”



To answer the third subsequent research question, this research found that the phoneme substitution that occurred the most was the /o/ instead of /ɑ/, being the word *isotropic* /ˌaɪsəˈtrɑpɪk, -ˈtroʊpɪk/ the one that 100% of the participants made such replacement in the second "o". The second "o" in *isotropic* has two possible phonemes: /ɑ/ or /oʊ/. The participants were instructed that both phonemes are acceptable; however, they showed preference for /ɑ/ because Latin a is a sound that Spanish has. Nonetheless, the collection of data showed that /ɑ/ was replaced by /o/. Another word that underwent such a change was *antioxidant* /ˌæntiˈɑksɪdənt, ˌæntaɪ/; 80% of the participants replaced /ɑ/ by /o/. Figure 3 also shows that the second most common phoneme substitution is /o/ instead of /oʊ/. Regarding this change, the word ***pr<u>o</u>pan<u>o</u>ic*** /ˈproʊpəˈnoʊɪk, ˌproʊ-/ was the one that scored the most mistake points. The reason that this word scored the highest punctuation is because it has the phoneme /oʊ/ two times, and L1 may have influenced the participants' pronunciation. Another word that underwent this change was *allotrope* /ˈælətroʊp/; the second "o" of this word stands for /oʊ/, and 100% of the participants replaced that phoneme. The third most common substitution is /ə/ instead of /ɑ/. The words *phosphate* /ˈfɒsfeɪt/ and *phosphorylation* /ˌfɑsfərəˈleɪʃən, fɑsfɔrə-, fɑsfɑr-/ were the most affected since 40% of the participants made said change. *Phosphate* was pronounced /fəsˈfeɪt/. The participants problably made the substitution because they placed the stress on *-phate,* and the general tendency is to reduce the vowels that are after and before the stressed syllable (Kelly, 2000, p. 67). Concerning *phosphorylation,* it was pronounced /fəsfərəˈleɪʃən/. The word *phosphorylation* derives from *phosphorylate* /ˈfɑsfərəˌleɪt, fɑsˈfɔrə-, -ˈfɑr-/. Although the suffix *–tion* moves the main stress of the word, the realization of /ɑ/ in the first syllable is maintained. The fourth substitution is /ə/ instead of /oʊ/. The words *antimony* /ˈæntəmoʊni/, *covalent* /koʊˈveɪlənt/, and *polar* /ˈpoʊlər/ were the ones that were

pronounced incorrectly; 60% of the participants made such a substitution. The fifth substitution is /o/ instead of /ə/. The word *methionine* /mɛˈθaɪənin, -nɪn/ scored the highest number of mistakes; 80% of the participants pronounced the letter "o" as /o/ instead of /ə/. The words *isotropic* /ˌaɪsəˈtrɑpɪk, -ˈtroʊpɪk/ and *anisotropic* /ænˌaɪsəˈtrɑpɪk, -ˈtroʊpɪk/ presented a challenge to the participants; the first "o" in both words stands for /ə/, and 60% of the participants pronounced /o/ instead. Hitherto, /o/ is responsible of 3 out of 4 substitutions; this reveals the influence of L1 when the participants have to cope with the pronunciation of the sounds that the letter "o" conveys.

On the other hand, the substitution of /ʌ/ instead of /oʊ/ takes the sixth most common substitution. Even though this substitution happened only with one word, which is *pol**o**nium* /pəˈloʊniəm/, all the participants made said substitution. Similar to previous findings, this pronunciation issues regarding the letter "o" agree with Derwing and Munro (2015) who state that one possible pronunciation mistake is "substitution" (p. 58). These authors also state that "new item" is responsible for the mistakes (p. 64); except /a/, the correct phonemes that the letter "o" conveys are inexistent in Spanish; therefore, the participants opted for using what they knew to complete the pronunciation task.

E. Limitations

Even though instruction about pronunciation of chemistry-related words was carried out during class time, the students may not have had enough time to internalize all the multiple irregularities that English pronunciation involves. Learners have their own internal syllabuses, which do not necessarily match instruction, as several authors have pointed out (Hutchison & Waters). Another limitation was that participants might have not been enthusiastic by the time they were recording their pronunciation, even though they

were motived to do so. Since they were recorded, nervousness might have affected their pronunciation.

F. Recommendations

Based on the findings of this investigation, three main recommendations are important to take into consideration for planning a future ESP course for people who are in the chemistry field; course designers have to incorporate ways to teach word stress, different pronunciations of the letter "o", diphthongs, and the final-silent-letter-e rule, which sometimes causes the vowel letters "a", "e", "i", "o", and "u" to sound like long vowels instead of the short ones.

Instructors should help students stress words correctly. This implies that the students have to identify the syllable that has the main stress in a word. Charts with words with the same number of syllables but different stress patterns might be created to make the stress change evident. Kelly (2000) uses the figures O, o, and . to indicate the main stress, secondary stress, and unstress respectively (p. 69), and Celce-Murcia et al. (2010) use three dots of different sizes (● ● ●) to illustrate the two main stresses and the unstress (p. 204). Table 4 provides an example of this.

Table 4.
Graphic representations of stress in words with two and three syllables

Two Syllables		Three Syllables	
(● ●)	(● ●)	(● ● ●)	(● ● ●)
(O o)	(o O)	(O o o)	(o O o)
enol	co**llide**	**che**mistry	di**sul**fide
luster	sus**pend**	**fu**llerene	po**lo**nium
solid		**mo**lecule	ti**ta**nium
sulfur		**al**cohol	se**le**nium

As a matter of practice, instructors might create a chart similar to the one in Table 4 with some blanks to fill in with words from a given list. This way, students can identify stress patterns in multisyllabic words. In relation to syllable stress, instructors should teach students the following four pronunciation tenets.

1. Instructors should let the students know that when the words have two syllables, the main stress will be on the first syllable most of the time (Kelly, 2000, p. 69); some examples are ***a****lloy*, ***ca****tion*, ***co****pper*, ***e****nol*, ***ke****to*, ***so****lid*, ***po****lar*, ***pro****cess*, and ***vo****lume*. A few words do not obey this rule, for example *co**llide*** and *sus**pend***. Concerning this fact, Avery, and Ehrlich (1992) state that "more than 90 per cent of all English nouns of two syllables are stressed on the first syllable" (67).

2. It is a good idea to teach the students that the main stress does not usually fall on prefixes, for example, ***an****isotropic*, ***ant****ioxidant*, ***bio****mimicry*, ***di****oxide*, ***di****ssociate*, ***radio****activity*, and ***tetra****chloride*. According to Carr (2013), the underlined prefixes create a new form of the root word; therefore, the main stress does not fall on them. (p. 79). According to Roach (2000) and Orion (1997), the exception to this rule is that when a pair of prefix+root words occur; one of which is a verb, and the other one is an adjective or a noun. The verb will have the primary stress on the root, whereas the noun or the adjective will have it on the prefix, for example, the noun conduct /ˈ**kan**dəkt/ and the verb conduct /kənˈ**dəkt**/ (p.110).

3. Instructors should also teach that some suffixes such as the Greek –graphy and the Latin –tion move the main stress of the word when they are added. Rogerson-Revell (2011) states that the affix –ic "is not stressed but the stress on the stem moves" (p. 145). For

example, from ***crys****tal*, the stress is moved to *crystall****og****raphy*, from *decar****box****ylase* to *decarboxy****la****tion*, from ***phos****phorate* to *phosphory****la****tion*, and from ***pro****pane* to *propa****no****ic*. In this regard, Carr (2013) states that the underlined suffixes are stress-shifting. Table 5 illustrates this shifting stress rule with more examples.

Table 5.
Stress shifting caused by suffixes

Suffix	Root	Derived word
-graphy	chrome	chromatography
	polar	polarography
-tion	condensate	condensation
	hydrogen	hydrogenation
	titrate	titration
	chelate	chelation
-ic	atom	atomic
	ion	ionic
	period	periodic

4. Students ought to learn that a single vowel letter can constitute a syllable in English, some examples are *bi****o****mimicry*, *co****a****lesce*, and *stoichi****o****metry*. Sometimes that single letter will receive the main stress, such as in ***e****nol* and ***e****thanol*.

Similarly, instruction that deals with the English vowels will be beneficial for students in order to improve their pronunciation. The L1 might lead to mispronouncing English vowels; therefore, the more accurate the pronunciation of the English vowels, the more understandable the speaker will be. In fact, according to Avery and Ehrlich (1992), the same vowel letter represents different sounds (p. 3). In this regard, words which are spelled with the letter "o" have to be given special attention since this letter represents

several sounds. Five principles about the pronunciation of words that contain the letter "o" are important to highlight. Thus, the following recommendations are originated from the second phase of this research.

1. O is realized as /ɑ/. EFL teachers should teach their students that there are four conditions in which the letter "o" stands for /ɑ/.

1.1 When the letter "o" precedes the suffix ***-graphy***, /ɑ/ is produced, for example, *crystall**o**graphy, galvan**o**graphy,* and *metall**o**graphy*.

1.2 In monosyllabic words, the letter "o" is sometimes realized as /ɑ/. Some examples are *b**o**nd* and *br**o**nze*.

1.3 In two-syllable and three-syllable words, when the letter "o" takes place in the first syllable, and that syllable is the accented one, the letter "o" stands for /ɑ/. For instance, *c**o**pper, s**o**lid, v**o**lume, c**o**mpound,* and *m**o**lecule*.

1.4 In four-syllable words, when the letter "o" occurs in the tonic syllable, it stands for /ɑ/ as in *sap**o**nify, taut**o**merize,* and ***o**xidizing*. Table 6 shows more examples of the previous pronunciation tendencies

Table 6.
Common realizations of the letter "o" as /a/

Realization 1.1	Realization 1.2	Realization 1.3	Realization 1.4
chromat**o**graphy	t**o**ng	str**o**ntium	hydr**o**lysis
polar**o**graphy	s**o**l	**o**smosis	man**o**meter
zym**o**graphy			pyr**o**lysis

2. **O is realized as /ə/.** EFL instructors ought to teach students that the letter "o" is realized as /ə/ in the following circumstances.

2.1 When the letter "o" and all simple vowels are immediately before or after the tonic syllable, /ə/ is produced. Some examples of this rule are *c**o**llide, is**o**tropic, p**o**lonium,* and the first "o" in *all**o**trope*.

2.2 The suffix ***-ous*** is pronounced /əs/ as in *gase**ous*** and *nitrogen**ous*****.**

3. O realized as /ɔ/. Students should learn that /ɔ/ is produced when the letter "o" is before r; for example, f**o**rmula and tetrachl**o**ride.

4. O realized as /ɑ/ or /ɔ/. EFL teachers should instruct learners that the particles *hol* or *nol* at the end of the words are pronounced with either /ɑ/ or /ɔ/. For example, *alcoh**o**l*, *en**o**l*, and *ethan**o**l*.

5. O realized as the diphthong /oʊ/. Finally, English students ought to learn that the letter "o" is realized /oʊ/ when the following conditions are given.

5.1 When the letter "o" is at the end of the words, /oʊ/ is usually produced, for example, *ket**o*** and *radi**o**activity*. Even though this last word does not end in o, it is a compound noun formed by *radi**o*** and *activity*. The word *radio* keeps is original pronunciation.

5.2 The prefix bio is pronounced / baIoʊ / as in ***bio**mimicry* or ***bio**chemistry*.

5.3 When the syllable co is a prefix, it is pronounced /oʊ/ as in *c**o**alesce*.

Students will benefit by grouping words that share a particular pronunciation issue such as the ones on Table 5 and 6, by giving students word examples that share the same realization of the letter "o", and by showing words that have the same spelling patterns of

diphthongs because according to Lewis (1997), "class time is better spent helping learners develop strategies for dealing with unknown items […], rather than laborious practice aimed at consolidating individual items" (p. 47).

Highlighting the pronunciation of chemistry-related words that have diphthongs is helpful for the students. English diphthongs can be classified in groups: three of them finish in /ə/, which are /ɪə/, /eə/, and /ʊə/. Three of them finish in /ɪ/ as in /eɪ/, /aɪ/, /ɔɪ/, and two of them finish in /ʊ/ as in /oʊ/ and /aʊ/. Students also need to know that one vowel letter can stand for a diphthong, as in *alkal**i**, antim**o**ny*, and *n**i**trate*. Similarly, some spelling patterns may be useful for the students to pronounce diphthongs correctly. Base on Kelly (2000), Roach (2000), and Rogerson-Revell (2011), the diphthongs have some common spelling patterns; the chemistry-related words under study are used to illustrate those patterns. Thus,

1. /eɪ/ is commonly spelled with a, as in *ur**a**nium*, *tit**a**nium*, and *r**a**dium*.

2. /aɪ/ is commonly spelled with i, as in *alkal**i*** and n**i**trogenous.

3. /ɔɪ/ is commonly spelled with oi or oy, as in *st**oi**chiometry* and *all**oy***.

4. /oʊ/ is commonly spelled with o, as in *antim**o**ny*, *p**o**lar*, and *pol**o**nium*.

Table 7 shows more examples of these pronunciation features.

Table 7.
Common letters to spell diphthongs

/eɪ/ spelled with a	/aɪ/ spelled with i	/ɔɪ/ spelled with oi	/oʊ/ spelled with o
den**a**ture	an**i**on	b**oi**l	amin**o**
distill**a**tion	b**i**nary	coll**oi**d	c**o**agulate
hydrogen**a**tion	ch**i**ral	endp**oi**nt	dip**o**le
v**a**por	**i**odine	metall**oi**d	g**o**ld
	isomer	p**oi**son	m**o**lar
	n**i**trogen		pr**o**ton

Similarly, the general case is that the final letter "e" is silent; therefore, the consonant next to it ends the previous syllable. This silent "e" usually affects the pronunciation of the last pronounced vowel by creating diphthongs and tense sounds from vowel letters. Accordingly, "a" sounds /eɪ/, "e" sounds /i/, "i" sounds /aɪ/, "o" sounds /oʊ/, and "u" sounds /yu/ (Avery & Ehrlich, 1992, p. 5). If the "e" were not part of the spelling of the word, the pronunciation of the last vowel letter would be a simple vowel sound. Hence, "a" sounds /æ/, "e" sounds /Ɛ/, "i" sounds /ɪ/, "o" sounds as /ɑ/, and "u" sounds /ʌ/). Thus,

1. /eɪ/ is commonly spelled with a, as in alk**a**ne, *anhydr**a**se*, and *nitr**a**te*.

2. /aɪ/ is commonly spelled with i, as in *coll**i**de*, *d**i**sulf**i**de*, and *hal**i**de* (although the last syllable can be pronounced -/laɪd/ or -/lɪd/).

3. /oʊ/ is produced when the letter "o" is between consonants and the word ends in a silent e, for example, the second "o" in *allotr**o**pe and isot**o**pe*, as well as others. However, some exceptions occur as in *br**o**nze*. Table 8 provides more examples that illustrate the influence of the final silent letter "e" to produce diphthongs.

Table 8.
Realization of diphthongs due to the final silent letter "e"

/eɪ/ spelled with a	/aɪ/ spelled with i	/oʊ/ spelled with o
b**a**se	actin**i**de	an**o**de
equ**a**te	brom**i**ne	azeotr**o**pe
filtr**a**te	fluor**i**de	cath**o**de
leach**a**te	nucleot**i**de	electr**o**de
methyl**a**te	nucl**i**de	ket**o**ne
titr**a**te		n**o**ble

Even though these three pronunciation rules are the general case as a consequence of the final-silent-letter-e rule, sometimes, the silent final "e" does not create a diphthong; two exceptions of this rule are *coal**e**sce*, and *latt**i**ce*.

Finally, ESL instructors should use symbols to represent the English phonemes to visualize the sounds. Using the International Phonetic Alphabet (IPA) symbols is one way to professionally write down the specific phonemes or the pronunciation of an entire word. These phonetic symbols might help the students to see the sounds that a written word stands for, and therefore, the students may work with specific sounds in order to correct their pronunciation. In conclusion, ESP instructors should draw the students' attention to the aforementioned points in order to improve the students' skills.

G. Recommendations for Further Investigations

A future investigation might repeat the purpose of this study but with a larger sample of participants in order to compare results; that comparison would validate or disagree from the results found in this research. Another recommendation is to focus on only one segmental aspect; it could be single vowels or diphthongs. Similarly, word stress would be another pronunciation area to explore more specifically.

Conclusion

The needs analysis of a group of chemistry students from the University of Costa Rica showed that the pronunciation of chemistry-related words is a problem for them. This research project could identify and rank five major pronunciation problems. Moreover, during the conduction of this project, the pronunciation of the letter "o" was focused because it has four realizations; it represented a challenge for the participants, whose L1 is Spanish. In Spanish, the realization of this letter is only one. Hence, this investigation identified the most common substitutions that the participants made when they were pronouncing the words. Based on the results, the researcher could compile pronunciation general tendencies in order to help students to cope English pronunciation. These general pronunciation tendencies are related to word stress, realizations of the letter "o", diphthongs, and the final-silent-letter-e rule. Although the examples provided are from chemistry, these general pronunciation tendencies can be used in any scientific field.

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Appendix A

Initial Questionnaire for the Chemistry Students

1- ¿Cuáles son las labores principales de un químico?

2- ¿En qué lugares puede trabajar un químico?

3- ¿Por qué usted como estudiante necesita inglés?

4- ¿Por qué usted como futuro químico necesitará inglés?

5- ¿Podría recomendar algún libro, autor o artículo que usted haya leído en inglés?

Appendix B

Questions for the Contact Person

1- ¿En qué año de la carrera están ellos?

2- ¿Por qué ellos necesitan inglés?

3- ¿En la universidad, cuando un estudiante consigue algún material en inglés, qué tienen que hacer normalmente con ese material?

4- ¿Cuáles son labores típicas de un químico ya graduado?

5- ¿Qué ventajas traería saber inglés a un químico?

6- ¿Conoce algún libro, artículo, o autor que me pueda recomendar que esté en inglés y que los estudiantes deban utilizar en clase?

Appendix C
Questionnaire for the Chemistry Students

Universidad de Costa Rica
Maestría Profesional en la Enseñanza del Inglés como Lengua Extranjera 2018

ENCUESTA PARA ESTUDIANTES DE QUÍMICA

Esta encuesta tiene como objetivo recolectar información para el diseño de un curso de inglés para estudiantes de la escuela de química de la Universidad de Costa Rica. Dicho curso se impartirá el segundo semestre del año en curso como parte de la práctica profesional de la Maestría en la Enseñanza del Inglés como Lengua Extranjera. La información suministrada será manejada con **discreción y confidencialidad**. Gracias por su sinceridad al completar este cuestionario.

I. INFORMACIÓN PERSONAL.

1. Marque la opción que indique su edad.

☐ 20-25 años ☐ 26-30 años ☐ 31-35 años ☐ 36-40 años ☐ 40 años o más.

2. Seleccione la casilla que indica el año de carrera en el que se encuentra.

☐ Primer año ☐ Segundo año ☐ Tercer año ☐ Cuarto año ☐ Quinto año

3. ¿Ha tomado cursos de inglés? ☐ Si. ☐ No. **Si no, vaya a la siguiente sección.**

4. Si ha tomado cursos de inglés, seleccione los lugares donde ha estudiado inglés.

☐ Pre-escolar ☐ Escuela ☐ Colegio ☐ Universidad

☐ Instituto ☐ Curso en línea ☐ Autodidacta ☐ Otro: _____

5. Con base en el dominio del inglés que usted posee, ¿cuál sería su nivel de desempeño en las siguientes áreas? Marque un nivel en cada habilidad.

Habilidad	Principiante	Intermedio	Avanzado
Escucha			
Habla			
Escritura			
Lectura			

II. INGLÉS EN LA UNIVERSIDAD

6. Marque la o las habilidades del inglés que usted usa en la universidad.

☐ Escucha ☐ Habla ☐ Escritura ☐ Lectura

7. Señale la frecuencia con la que usted usa las anteriores habilidades en el idioma inglés en la universidad.

Habilidad	Nunca	Pocas veces	Muchas veces	Siempre
Escucha				
Habla				
Escritura				
Lectura				

8. Marque las actividades en las que usted necesita **inglés** en su carrera.

☐ Leer artículos.

☐ Ver videos.

☐ Leer capítulos de libros.

☐ Recibir clases con profesores extranjeros.

☐ Escribir reportes.

☐ Describir procesos químicos oralmente.

☐ Escribir correos electrónicos.

☐ Explicar fórmulas químicas oralmente.

☐ Escribir investigaciones.

☐ Recibir clases con profesores extranjeros.

☐ Ir a conferencias.

☐ Búsqueda en información en internet.

☐ Otro:_____

III. INGLÉS EN SU FUTURO PROFESIONAL.

9. Como futuro profesional en química, seleccione la o las actividades que serán llevadas a cabo en inglés.

Necesito inglés para…

☐ Leer investigaciones para actualizarme.

☐ Ver videos para actualizarme.

☐ Escribir correos electrónicos.

☐ Escribir investigaciones.

☐ Asistir a conferencias.

☐ Hablar con colegas de otros países.

☐ Hablar con clientes.

☐ Hablar con empleadores.

☐ Explicar oralmente cambios en fórmulas químicas.

☐ Explicar oralmente ventajas en nuevas fórmulas químicas.

☐ Conversar telefónicamente.

☐ Optar por maestrías en el extranjero.

☐ Otro:_____

IV. PREFERENCIAS

10. Escoja las opciones que completen la siguiente frase. **Puede escoger mas de una.**

En el curso de inglés para estudiantes de química, me gustaría…

- ☐ Trabajar solo.
- ☐ Trabajar en parejas.
- ☐ Trabajar en grupo
- ☐ Entablar conversaciones.
- ☐ Ver videos.
- ☐ Escuchar audios.
- ☐ Hacer presentaciones orales.
- ☐ Leer textos cortos.
- ☐ Sugerir temas de interés personal.
- ☐ Leer secciones de investigaciones.
- ☐ Explicar procesos químicos oralmente.
- ☐ Explicar oralmente razones para cambiar fórmulas químicas.
- ☐ Explicar oralmente razones para mejorar fórmulas químicas.
- ☐ Escribir razones para cambiar fórmulas químicas.
- ☐ Escribir razones para mejorar fórmulas químicas.
- ☐ Otro:_____

11. Seleccione el nivel de dificultad que cada habilidad en inglés presenta para usted.

Habilidad	Muy Fácil	Fácil	Difícil	Muy difícil
Escucha				
Habla				
Escritura				
Lectura				

12. ¿Qué habilidad le gustaría que el curso de inglés para estudiantes de química que se impartirá el segundo semestre del 2018 se enfocara? Enumere las habilidades del 1 al 4, donde 1 es la de mayor énfasis y 4 es la de menor énfasis.

Habilidad	Énfasis
Escucha	
Habla	
Escritura	
Lectura	

13. ¿Qué espera usted aprender en el curso de inglés para estudiantes de química?

_____

_____

14. Complete la siguiente frase con **UNA** opción.

Me gustaría que el curso de inglés para estudiantes de química fuera:

☐ Lunes y miércoles de 5:00 pm a 7:00 pm

☐ Lunes de 5:00 pm a 8:00 pm

☐ Miércoles de 5:00 pm a 8:00 pm

15. Justifique la escogencia anterior.

_____

_____

¡MUCHAS GRACIAS!

Appendix D

University of Costa Rica

School of Modern Languages

M.A. Program in Teaching English as a Foreign Language

Diagnostic Test for Chemists

Total points: 85		Total Score: _____
Listening Score:_____	Reading Score:_____	Speaking Score:_____

Name:_____

Date:_____

General Guidelines

1. Read instructions carefully.
2. Use black or blue ink.
3. Write clearly and orderly.
4. Dictionaries, cellphones, and any electronic devices **are not allowed** while you are taking this test.
5. You have **1 hour and 30 minutes** to take the reading and listening sections.
6. Ask the test administrators if you have any questions concerning your tasks.

Listening Section

Total Points: 25 **Points obtained:_____** **Score:_____**

Part I. Listen to Simple Chemistry Magic Trick and do the following tasks.

Audio taken from: https://www.youtube.com/watch?v=xoD4FUAuDTM

1. Fill-in-the blanks. Complete the following sentences based on the audio. 3 pts. / ____

1. The speaker uses five _____ to perform the experiment.

2. The speaker adds one or two _____ of _____in each flask.

2. Match. Match the two columns to indicate the color change in each solution. 3pts. / ____

1. From green to ___	a. fade
2. From orange to ___	b. blueish
3. From yellow to ___	c. red

Part II. Listen to the audio Importance of pH in Everyday Life and do the following tasks.

Audio taken from: https://www.youtube.com/watch?v=x-nI3Ws7nxQ

1. Questions. Answer the following questions. 6 pts. / ___

1. What is the range of pH that the human body works in?

_____

2. How is it called when the pH of rainwater is less than 5.6?

_____

3. What does the human stomach produce to help the digestion of food?

_____

4. What chemical do people take to get rid of the pain caused by the acid in the stomach?

_____

5. What is the hardest substance in the body?

_____

6. What do bacteria in the mouth produce?

_____

2. Fill-in-the-blanks. Use acids to complete these statements. 4 pts. / ____

1. _____ is acetic acid.

2. _____ is tartaric acid

3. _____ is oxalic acid

4. _____ _____ is methanoic acid

Part III. Listen to the audio What are polymers? Then, do the following tasks.

Audio taken from: https://www.youtube.com/watch?v=bJi8x7bKHqQ

1. Questions. Answer the following questions based on the audio.

1- Besides plastic, what other 3 forms can polymers take? 3 pts. / ____

1.1_____

1.2_____

1.3_____

2- What will the properties of polymers depend on? 2pts. / ____

2.1_____ and _____

2.2 _____

3- What animal do some scientists study to improve polymers? 1 pt. / ____

_____

2. Note taking. Complete this chart with three characteristics that controlled polymer assembly will allow materials to have. 3 pts. / ____

Materials:
1._____
2._____
3. _____

Reading Section

Total Points: 30 Points obtained:_____ Score:_____

Part I. Read the following chart.

Common name	Chemical name	Molecular Formula	Notes
Baking Powder	Sodium bicarbonate	$NaHCO_3$	Used in baking when it reacts with other ingredients releasing carbon dioxide (CO_2), helping dough rise.
Limestone	Calcium carbonate	$CaCO_3$	A sedimentary rock consisting mainly of calcite and/or aragonite. Limestone has been widely used in architecture worldwide.
Vinegar	Acetic acid, ethanoic acid	$C_2H_4O_2$	Food seasoning and various household cleaning uses.
Vitamin C	Ascorbic acid	$C_6H_8O_6$	Essential vitamin.

Taken and adapted from: http://www.ivyroses.com/Chemistry/GCSE/Common-and-Trade-Names-of-Chemicals.php

1. Matching. Match the next two columns. 4 pts. / ____

1. It is used in architecture. ____ a. acetic acid
2. Helps dough rise ____ b. ascorbic acid
3. Vitamin ____ c. $NaHCO_3$
4. Food seasoning ____ d. limestone

2. Fill-in-the-blanks. Complete the following sentences. 3 pts. / ____

1. Two acids for cleaning are _____ and _____

2. _____ is released when sodium bicarbonate reacts with some ingredients.

3. Short answers. Answer these questions. 3 pts. / ____

1. What is the molecular formula of baking powder?

_____

2. What is the chemical name of a sedimentary rock?

_____

3. What is the common name for $C_6H_8O_6$?

_____

Part II. Read the following text.

The Equipment You Will Encounter and Their Functions

A beaker is a common container in most labs. It is used for mixing, stirring, and heating chemicals. Most beakers have spouts on their rims to aid in pouring. They also commonly have lips around their rims and markings to measure the volume they contain, although they are not a precise way to measure liquids. Beakers come in a wide range of sizes. Because of the lip that runs around the rim, a lid for a beaker does not exist. However, a watch glass can be used to cover the opening to prevent contamination or splashing.

Also known as a boiling flask, the Florence flask has a round bottom and a long neck. It is used to hold liquids and can be easily swirled and heated. It can also easily be capped by rubber or glass stoppers. Once again, safety dictates that this flask never be heated when capped. Pressure build-up and explosions can and do occur.

A test tube is a glass tube with one end open and the other end closed. The closed end is rounded. Test tubes are used to hold small samples. They are primarily used for qualitative assessment and comparison. A common place to see these is the biochemistry lab. When a large number of samples need to be tested and compared, test tubes are used to make this easier. They are also easily capped with a rubber or glass stopper. They are generally held in a test tube rack specifically designed for the purpose. If the test tubes become unsafe to touch with bare hands (whether due to heat or another reason), test-tube tongs can be used to move them. Never heat a capped test tube.

A volumetric flask is a round flask with a long neck and flat bottom. It is used to measure an exact volume of liquid. There is a small line on the neck that indicates how far to fill the bottle (use the bottom of the meniscus). They come with special caps that will not let anything in or out.

Taken and adapted from: https://owlcation.com/stem/A-Chemistry-Guide-List-of-Common-Laboratory-Equipment-Names-and-Uses

1. Fill-in-the blanks. Complete these sentences using information from the text. 3pts. / __

1. A _____ is to stir, mix, and measure chemicals.

2. A _____ has a narrow neck and expands toward its base.

3. A _____ is used to assess and compare qualitatively.

2. Identifying. Write five characteristics of a volumetric flask. 5 pts. / ____

Characteristics of a volumetric flask
1. _____
2. _____
3. _____
4. _____
5. _____

3. Questions. Answer the following questions. 2 pts. / ____

1. What is another name for a Florence flask?

_____

2. Where are test tubes generally held?

_____

Part III. Read the following Introduction and Conclusions of a research paper called Applications of the Sol–Gel Process Using Well-Tested Recipes.

Introduction

Generally speaking, glass is defined as an amorphous body, solid at room temperature, obtained by melting together siliceous sand and alkali carbonates. Even if such a definition is valid in most cases, recent synthetic routes allow the preparation of glassy materials without melting (1). These sol–gel processes constitute an important part of so-called "soft chemistry" (2). The sol–gel process has many technological applications (3, 4), such as production of coatings with specific optical properties, organic–inorganic hybrid materials, and supports for culture media in biology. A wide literature is devoted to this increasingly important chemistry. Unfortunately, the procedures described are often complex and require specific devices or use highly moisture-sensitive chemicals (such as alkali alcoholates), making them difficult to perform outside of a research laboratory. Besides, the reactions are often very long, taking tens or even hundreds of hours. For these reasons, the practical educational use of the sol–gel process is not easy. In this paper, we present a few simple recipes that explore several major applications of the sol–gel process. These are not our entirely original work, but rather selections, improvements, modifications, and completions of published procedures. Most of the published accounts are incomplete in the sense that small but very important details are not given. The success of the experiments is highly sensitive to many parameters, and hence the rapid manufacture of "nice" materials is not at all straightforward. This is why we feel that the proposed recipes are of practical use in teaching soft chemistry; they were tested and modified until we were quite satisfied with the results. The reactions take place within a few hours, thus producing observable materials in a short time

Conclusions

We have described simple synthetic procedures leading to various sol–gel products. In our opinion, these recipes are rapid, easy for students to follow, and illustrative of the numerous possibilities of the sol–gel process. The longest experiments may be begun one day, left to stand for a period of time, and finished during a following week. Owing to the growing importance of soft chemistry, demonstrative experiments like these could be advantageously integrated into under-graduate chemistry programs. Still further developments are possible, such as incorporation of various colored elements or molecules within the gels. Photochromic silica xerogels could be easily obtained by encapsulation of optically active organic compounds. Characterization of the materials by X-ray diffraction or electron microscopy would also be of interest.

Taken and adapted from: A. Celzard; J. F. Marêché. (2002). Applications of the Sol–Gel Process Using Well-Tested Recipes. *Journal of Chemical Education. 79(9), 854-859.*

1. Questions. Infer the answer to these questions based on the text.

1. Based on the definition of glass, why is this investigation innovative? 1pt. / ____

_____

2. What is the purpose of the research paper? 1pt. / ____

_____

2. Multiple choice. Choose one option to complete each statement. 2 pts / ____

1. The research paper is mainly addressed to _____.

a. professional chemists

b. students of chemistry

c. glass industry

d. future chemists

2. Based on the Introduction and Conclusions, in their research paper, the authors provided a list of _____.

a. benefits of glass

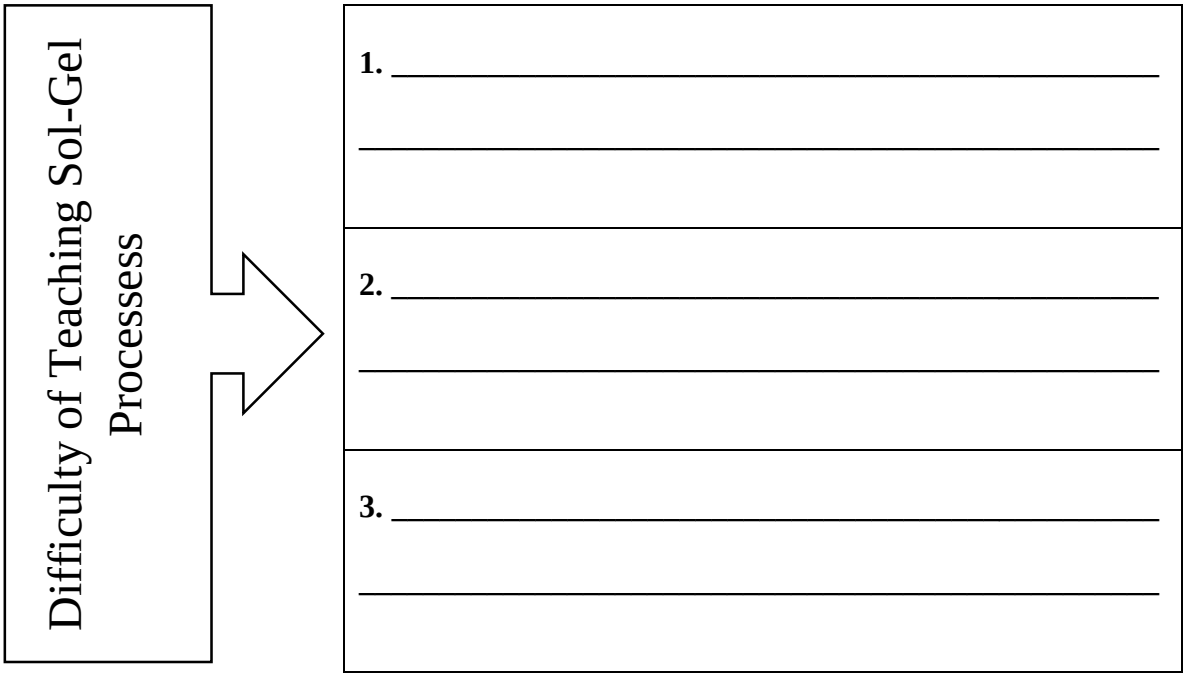
b. technological chemical innovations

c. advantages of soft chemistry

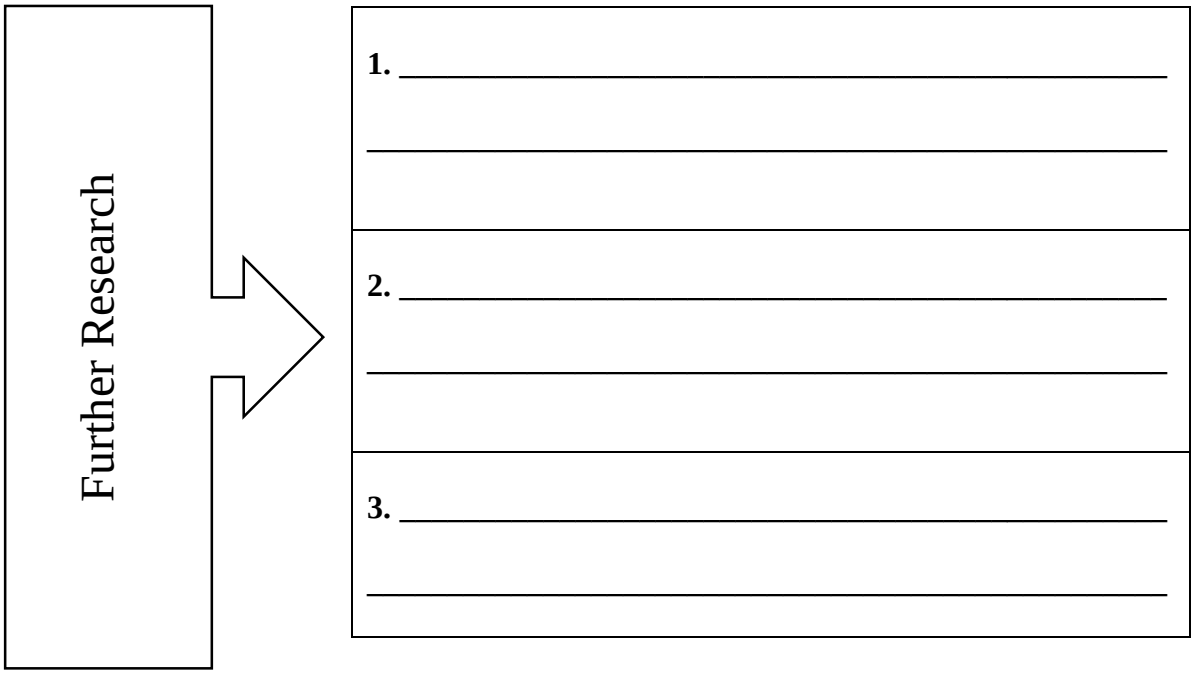
d. ways to elaborate sol–gel products

3. Graphic Organizers. Complete these graphic organizers to answer these questions.

1. What are three reasons why teaching sol-gel is difficult? 3pts. /____



2. What are 3 recommendations for possible further studies? 3 pts. / ____



Speaking Section

Total Points: 30 Points obtained:_____ Score:_____

Warm up: Test administrators will ask the participants the following questions to relax them and prepare them for the speaking task.

1- How are you?

2- What is your name?

3- How much of your degree have you completed?

4- How many courses are you taking this semester?

5- Why are you studying chemistry?

Once the participant feels comfortable, the test administrators will start the evaluation by giving the participants the following ESP situations.

Situation 1.1 You are hired to work in a laboratory that is new, but it does not have any equipment. You have to state a list of six tools that you need in the lab. Use the card to help you. 6 pts. / ____

Picture taken from: http://www.rfid-locker.co/Chemistry-Lab-Clip-Art-Clipart.html

Situation 1.2 From the previous list, you have to select two tools and explain what they are for. Please, describe what they look like. 4 pts. / ___

Situation 2.1 Since you are working in a lab, what are three safety guidelines that are necessary to be safe. 3 pts. / ___

Situation 2.2 What are three common accidents that happen in chemistry laboratories? 3 pts. / ____

Situation 2.3. Our company wants you to develop a new product for cleaning. What are two questions you need to ask in order to get more information about the product and its usage. 4 pts. / ____

Situation 3.1. You are a presenter in a conference. You have to explain the water molecule to your audience. You will receive a card with the water molecule and some guidelines regarding what you can speak about. 5 pts. / ____

Situation 3.2. You are a speaker at a conference in Japan. Part of your presentation is about different sugars and how they affect our bodies. At the end, a student in the audience asks you the following questions: ¨On a chemical level, what is the difference between glucose and fructose?¨

You will be given a card with the chemical compounds of both sugars along with some speaking prompts to guide you. Use the prompts, as well as your own knowledge, to answer the student`s question and compare and contrast the two sugars. 5 pts. / ____

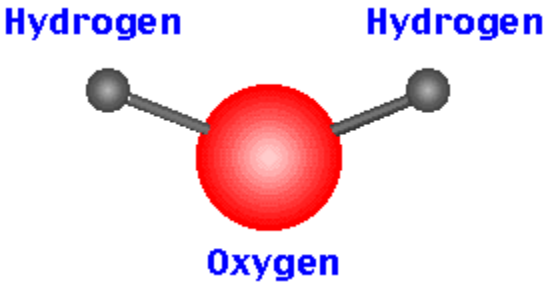
Wind down: Test administrators will indicate that the oral test has finished. Also, test administrators will thank the participation and will encourage the participants to continue studying English as well. Moreover, testers will ask the participants if they have any questions (Omaggio, 2001).

SITUATION 3.1. CARD

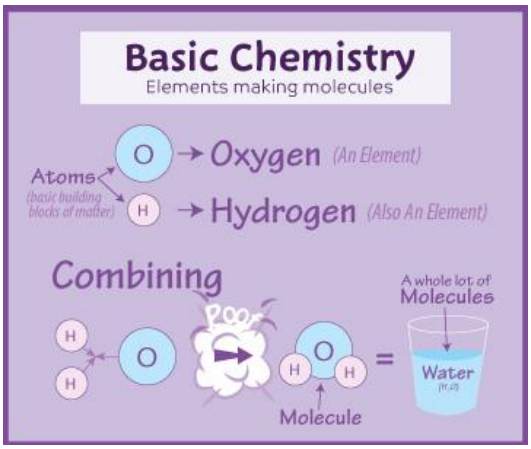
Water Molecule Card

Prompts to guide your response

1. Physical properties
2. What does it mean that water is electronegative?
3. What bonds are present in the water molecule?
4. How does water go up in tress against the gravity in plants? → Cohesion.
5. Why is water polar?
6. Why can water dissolve other molecules?
7. Water vrs Temperature: Evaporation, boiling temperature.



Pict. 1



Pict 2

Pictures taken from:
Pict 1:
https://www.google.com/search?q=water+molecule+structure&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjGw_KK4bPaAhUM71MKHRyqAiQQ_AUICigB&biw=1600&bih=794#imgrc=yS-S6AKtnqvGwM:

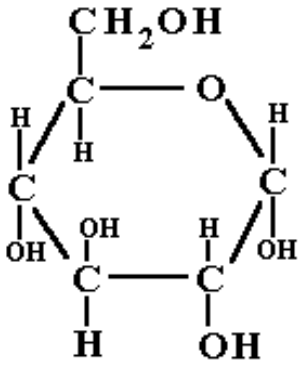
Pict. 2: https://www.biotoy.com/en/learn/

SITUATION 3.2. CARD

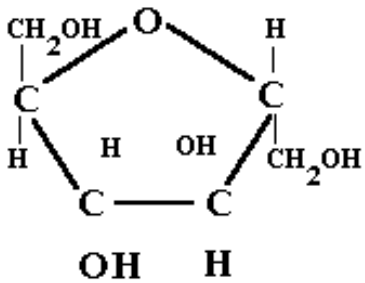
Glucose vrs Fructose Card

Prompts to guide your response

1. What is the chemical structure of each sugar?
2. What is a dehydration reaction?
3. Is the molecular formula the same for both sugars, or different?
4. How do they differ in ring structure?
5. Which sugar is more soluble, and why?



Glucose



Fructose

Picture taken from: https://u.osu.edu/cbcundergrad/category/courses/

Diagnostic Test Answer Key

Listening Section

Part 1

1. Fill-in-the blanks. 1. flasks 2. Drops - bleach

2. Match. b c a

Part 2.

1. Questions.
1. The human body works within the pH range of 7.0 to 7.8.
2. It is called acid rain.
3. The stomach of a human body produces hydrochloric acid.
4. magnesium hydroxide
5. calcium phosphate is the hardest substance in the body
6. Acids

2. Fill-in-the-blanks.

1. Vinegar is acetic acid
2. tamarind is tartaric acid
3. tomato is oxalic acid
4. ant sting which is methanoic

Part 3.

1. Questions.

1.1 polymers can be synthetic or natural DNA
1.2 proteins
1.3 cellulose

2.1 atoms and molecules it contains
2.2 how they're connected

3. Spiders

2. Note taking.

1. will be easier to recycle 2. can fix themselves after they're damaged,
3. respond when exposed to light or electricity.

Reading Section Answer Key

Part 1.

Answers: 1= d 2= c 3 = b 4 = a

Answers: 1. Acetic acid, ethanoic acid 2. carbon dioxide (CO_2)

Answers: 1. $NaHCO_3$ **2.** Calcium carbonate **3.** Vitamin C

Part 2.

1. Fill-in-the-blanks. 1. beaker 2. Florence flask 3. A test tube

2. Identifying. 1. Round 2. with a long neck 3. flat bottom.
4. There is a small line on the neck. 5. They come with special caps.

3. Questions:

1. a boiling flask,

2. They are generally held in a test tube rack specifically designed for the purpose

Part 3.

1. Questions.

1. Even if such a definition is valid in most cases, recent synthetic routes allow the preparation of glassy materials without melting (1).

2. We present a few simple recipes that explore several major applications of the sol–gel process.

2. Multiple choice. 1. b 2. d

3. Graphic organizers.

1. The procedures described are often complex.
They require specific devices or use highly moisture-sensitive chemicals.
The reactions are often very long.

2. Incorporation of various colored elements or molecules within the gels.
Photochromic silica xerogels could be easily obtained by encapsulation of optically active organic compounds.
Characterization of the materials by X-ray diffraction or electron microscopy.

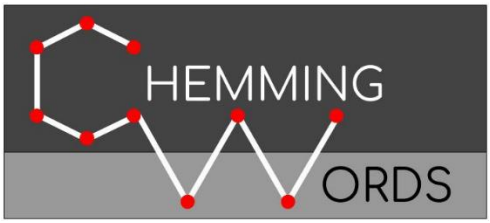
Appendix E

Unit Task Assessment Rubric
Oral Proficiency Rubric

Student`s Name: _____ Total Points Obtained:____ / 30 Grade: ____ %

	Excellent = 5 Points	**Very good = 4 Points**	**Good = 3 Points**	**Average = 2 Points**	**Poor = 1 Point**
Task Completion	Task is carried out with excellence. All aspects of the task are covered and the requirements are fulfilled.	Task is carried out very well. Almost all aspects are covered, and most requirements are fulfilled.	Task is carried out well, and many of the important aspects are covered. Lacks a few of the requirements.	Task is somewhat carried out, however, many of the aspects and requirements are lacking.	Task is hardly carried out and almost all aspects and requirements are lacking.
Content	Content is rich in detail and the response demonstrates a clear understanding of the topic through explanations and examples.	Content has a lot of detail, and the response demonstrates a very good understanding of the topic through explanations and examples.	Content has enough detail to demonstrate a good understanding of the topic. Explanations and examples are provided.	Content has some detail and demonstrate that the topic is somewhat understood. Explanations and examples are minimal.	Content has no or very limited detail. Demonstrates poor understanding of topic. No explanations or examples are provided.
Vocabulary	Vocabulary used is excellent and very appropriate for the task and allows for very clear communication of ideas.	Vocabulary used is good and appropriate for the task and allows for clear communication of ideas.	Vocabulary used is appropriate for the task and allows for communication of ideas.	Vocabulary used is somewhat appropriate for the task and somewhat allows for communication of ideas.	Vocabulary used is not appropriate for the task and does not allow for clear communication.
Pronunciation	Pronunciation is very clear and correct for almost all of the words, and enables excellent communication.	Pronunciation is clear and correct for most of the words, and enables great communication.	Pronunciation is clear and correct for many of the words. Although some words are mispronounced, clear communication still takes place.	Pronunciation is somewhat clear and correct. Many words are mispronounced and communication is somewhat hindered.	Pronunciation is mostly unclear and incorrect. Most words are mispronounced and clear communication does not take place.
Accuracy	Accuracy is high and control of grammatical structures is demonstrated.	Accuracy is very good and control of many grammatical structures is demonstrated.	Accuracy is good and although there are some errors, general control of grammatical structures is demonstrated.	Accuracy is moderate and many errors are made. Use of different grammatical structures is limited.	Accuracy is low and no control of grammatical structures is demonstrated.
Fluency	Fluency is high and there are very few long pauses. Communication flows with ease.	Fluency is very good and there are very few long pauses. Communication flows well.	Fluency is good although there are some pauses. Communication flows appropriately.	Fluency is moderate and there are many long pauses and breaks in communication.	Fluency is low and there are several long pauses and breaks which disrupt the flow of communication.

Appendix F
English Course for UCR Chemistry Students



University of Costa Rica
Master's Degree in Teaching English as a Foreign Language
Instructor: Erick Oses Ilama
Schedule: Wednesday 5:00 pm - 8:00 pm
Place: Chemistry Building, Room 113

I. Course Description

Chemming Word is a speaking and listening course for undergraduate students from the School of Chemistry at the University of Costa Rica. Its purpose is to develop communicative competence by focusing on the improvement of speaking and listening skills. This course will use real-world tasks as a method to learn English. Tasks and their outcomes will promote the development of speaking and listening skills along with the ability to interact in social academic settings such as conferences. In addition, emphasis will be placed on the acquisition of relevant chemistry vocabulary.

Students will learn to identify main ideas and general messages in a speech, give an academically structured speech to an audience, and interact with chemists and chemistry students at a conference through group and pair work, games, and whole-group activities.

This course consists of three units and aims to develop students' level of confidence when speaking and interacting with others and provide individualized feedback to promote success. For the purpose of this course, reading will serve as a complementary macro skill to provide input for the tasks, and writing will be targeted in post tasks. This way, the four macro skills will be integrated in the course.

II. Goals and Objectives

Goals

By the end of the course, students will be able to:

1. demonstrate comprehension of academic chemistry-related audio clips, presentations, and speeches by analyzing meaning and structures.
2. interact with members of the science community in a formal conference setting regarding chemistry-related topics with intelligibility and comprehensibility.
3. deliver effective speeches about chemistry to an audience of chemistry students, chemists, and stakeholders by communicating information in a clear and concise manner.

General Objectives

By the end of the unit 1, students will be able to:

1.1 effectively identify the global meaning in an academic speech related to chemistry by taking notes and filling in graphic organizers.

1.2 effectively identify the supporting details in an academic speech related to chemistry by taking notes and filling in graphic organizers.

1.3 adequately identify cohesive devices and connectors in an explanation by analyzing a speech transcript.

By the end of the unit 2, students will be able to:

2.1 appropriately request information from a speaker by asking specific direct questions about a topic presented at a conference.

2.2 appropriately request information from a speaker by asking indirect questions about a topic presented at a conference.

2.3 adequately ask for clarification by repeating, restating, and summarizing ideas.

2.4 interact with participants at a conference by correctly stating an opinion about the topic of the conference.

By the end of the unit 3, students will be able to:

3.1 appropriately deliver a short speech by conveying the global idea and supporting details in an academic manner.

3.2 appropriately use cohesive devices and connectors in an explanation by organizing the target words into a speech.

3.3 accurately answer questions in a clear and concise manner regarding chemistry-related topics by simulating a conference questions and answers session.

III. Methodology

This course will use tasks and outcomes to achieve the listening and speaking goals outlined in the Course Description. Students are expected to participate actively in class and collaborate with peers in order to reach the desired outcomes. Common activities will include presentations regarding chemical processes and formulas, academic conference simulations, reading research articles as a source of information, taking notes while listening to audio clips, games, and speeches. There will be both individual tasks as well as group/pair tasks at different stages of each class session. In order to maximize exposure to the language, it is recommended that students attend all class sessions. Attendance is an important part of success in this course, and will give students the opportunity to practice by interacting with their teacher and classmates.

IV. Assessment

The course will evaluate the following assessment tasks.

Achievement Task 1…….25 %

Achievement Task 2…….25 %

Achievement Task 3…….25 %

Assessment Portfolio …….25 %

Total……..100 %

V. Contents

The purpose of this course is to develop the speaking and listening skills of moderate proficiency level chemistry students. Meaningful interactions will be prioritized, and vocabulary acquisition will be emphasized throughout each lesson of the course. Due to allotted time given to the execution of the course, the content has been divided into three units:

Unit 1: Listening to Chemists

Unit 2: Asking for Chemistry Information

Unit 3: Interacting with Chemists

VI. Time Table

Unit 1

August 15……. Holiday

August 22……. Lesson 1

August 29……..….. Lesson 2

September 5……... Lesson 3

September 12 …..…. Assessment

Unit 2

September 19…….…. Lesson 4

September 26…….…. Lesson 5

October 3……. Lesson 6

October 10……..…. Lesson 7

October 17…… Assessment

Unit 3

October 24……..….. Lesson 8

October 31……. Lesson 9

November 7……..… Lesson 10

November 14……. Assessment

November 21…… Graduation Ceremony

Appendix G

Unit Evaluation

Course: Chemming Words **Instructors: E. Oses and M. Chinambu**

Dear student,

You will find some statements that intend to evaluate the unit. Thanks for completing this survey.

Instructions: Check the box that best expresses your opinion. Use the following scale.

Scale: 1. Strongly agree 3. Partly disagree

2. Partly agree 4. Strongly disagree

The unit	**1**	**2**	**3**	**4**
1. dealt with chemistry topics.				
2. had diverse chemistry topics.				
3. taught me English aspects.				
4. was well organized.				
5. achieved the set goals.				
6. used appropriate materials to learn .				
7. had variety of class dynamics.				
8. had lessons that helped me to learn English.				
9. had tasks that I need to perform as a chemistry student.				
10. had tasks that I need to perform as a future chemist.				
11. smoothly increased the difficulty level.				
12. only evaluated the contents of the unit.				

Instructions: Complete the following statements.

1. I liked that the unit _____

_____

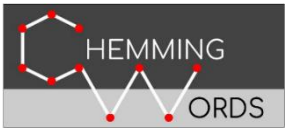
2. I disliked that the unit _____

_____

3. Being 1 the lowest grade and ten the highest one, I would give the unit a _____

Appendix H

Course Evaluation



Course: Chemming Words **Instructors: E. Oses and M. Chinambu**

Dear student,

You will find some statements that intend to evaluate the course. Thanks for completing this survey.

Instructions: Check the box (X) that best expresses your opinion. Use the following scale.

Scale: 1. Strongly agree 2. Partly agree

3. Partly disagree 4. Strongly disagree

The course	1	2	3	4
1. was well organized.				
2. dealt with topics that I need in my scientific field.				
3. achieved the set goals.				
4. helped me to learn English.				
5. fulfilled my expectations.				
6. took into consideration my suggestions about topics to study.				
7. used appropriate materials.				
8. only evaluated the proposed contents.				
9. evaluated tasks that I was prepared for.				
10. gradually increased the level of difficulty.				
11. will help me academically.				
12. will help me professionally.				

Instructions: Complete the following statements by checking the best phrase.

1. The course_____ my expectations.

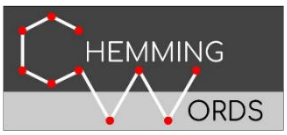
☐ didn't fulfill ☐ partly fulfilled

☐ vaguely fulfilled ☐ strongly fulfilled

2. Being 1 the lowest grade and ten the highest one, I would give the course _____

Appendix I

Instructor Evaluation



Course: Chemming Words **Instructors: E. Oses and M. Chinambu**

Dear student,

You will find some statements that intend to evaluate the instructor. Thanks for completing this survey.

Instructions: Check the box that best expresses your opinion. Use the following scale.

Scale:

1. Strongly agree 2. Partly agree 3. Partly disagree 4. Strongly disagree

The instructor:_____	**1**	**2**	**3**	**4**
1. was respectful to the students.				
2. used time effectively.				
3. answered my questions clearly.				
4. gave instructions clearly.				
5. provided feedback to the class.				
6. provided individual feedback.				
7. orderly conducted the class activities.				
8. promoted a friendly learning atmosphere.				
9. was available when I needed help.				

Instructions: Complete the following statements.

1. The instructor _____ my learning process.

☐ didn't guide ☐ somewhat guided

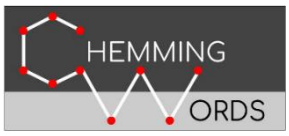
☐ lightly guided ☐ strongly guided

2. I think the instructor should _____

_____

3. Being 1 the lowest grade and ten the highest one, I would give the instructor _____

Appendix J



Learning Journal

Course: Chemming Words **Instructors: E. Oses and M. Chinambu**

Unit: _____ Lesson: _____ Date: _____

Topic of the Lesson:_____

My Predictions

1. I predict that I will learn about

_____

_____

2. I predict that I will hear words like

_____

_____

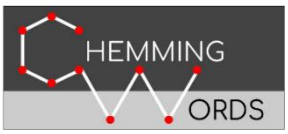
3. I predict that I will have to use strategies like_____

_____

Date:_____

1	Today's lesson was about _____ I learned the following **chemistry words** 1. _____ 5. _____ 2. _____ 6. _____ 3. _____ 7. _____ 4. _____ 8. _____
2	I learned these **useful expressions** 1._____ 2._____ 3._____ 4. _____ 5. _____
3	I learned a **strategy** to _____ _____
4	I could **easily** _____ _____
5	It was **difficult to** _____ _____

Appendix K



Unit Recording Self-Assessment

Unit:_____

Instructions: Read the following questions. Then, listen to your own unit assessment task recording and answer these questions.

1. Did you express your ideas clearly?

_____

2. Did you mispronounce words? If so,

_____

3. What words did you mispronounce?

_____

4. Did you use any of the strategies that you learned in class? If so,

_____

5. What strategy or strategies did you use?

_____

6. Were you able to improve on any recurrent mistakes made in class? If so,

_____

7. What was that mistake?

_____

8. Did you hesitate when you were performing the task? If so,

_____

9. Why do think you hesitated?

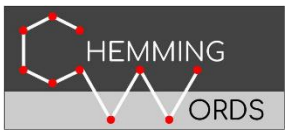
_____

10. What would you like to correct?

_____

11. Being 1 the lowest grade and ten the highest one, you would grade your performance with a _____

Appendix L



Assessment Portfolio

Course: Chemming Words **Instructors: E. Oses and M. Chinambu**

Student's name: _____

INTRODUCTION

This assessment portfolio is about

_____

_____

_____

The purpose of this assessment portfolio is to

_____

_____

_____

_____

Appendix M

Lesson Plan

Unit 1: Listening to Chemists **Lesson 1**

Course: Chemming Words **Instructor:** Erick Oses Ilama **Date:** August 22, 2018

Unit Goal: By the end of the unit, the students will be able to demonstrate comprehension of academic chemistry-related audio clips, presentations, and speeches by analyzing meaning and structures.

General Objective: By the end of the lesson, the students will be able to effectively identify the global meaning in an academic speech related to chemistry by taking notes and filling in graphic organizers.

Specific Objectives: At the end of the lesson, the students will be able to:

1. accurately identify the importance of green chemistry by orally stating ideas based on a video.
2. correctly match concepts of green chemistry and their descriptions by looking for a partner to match with.
3. properly identify four tips to be a good listener by watching a video and completing a table.
4. correctly show understanding of key words by filling in blanks in sentences.
5. successfully identify the three main ideas of a speech about green chemistry by completing a table.
6. correctly identify the main idea of a written excerpt from a video by writing it down.

Abbreviations: T=Teacher, Ss=Students, St=Student, H=Handout, =Listening, R=Reading, S=Speaking, W=Writing, M=Materials

Materials:

Video 1: What is Green Chemistry? Taken from: https://www.youtube.com/watch?v=B45LMANkcKI
Video 2: How to Improve Your Listening Skills. Taken from: https://www.youtube.com/watch?v=D6-MIeRr1e8&t=5s
Video 3: Green Chemistry: The Foundation of a Sustainable Future? Taken from: https://www.youtube.com/watch?v=OopkzZpppzg
Video 4: Intellectual Ecology, Green Chemistry. Taken from: https://www.youtube.com/watch?v=TL1zbAJIaDI
M1: 12 Principles of Green Chemistry. Taken from: https://www.acs.org/content/acs/en/greenchemistry/what-is-green-chemistry/principles/12-principles-of-green-chemistry.html

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
	Ice Breaker Ss introduce themselves. T introduces the course. The syllabus is read.	S R	My name is… I am in the ____ year of my major.	Ice Breaking.	10 min
	Opening Ss are told that the topic of the lesson is Green Chemistry, and the objective of the lesson is to get general ideas form a video. Ss work on their portfolio. Then, ss share their predictions orally.	W S	I think I will learn about… I think I will hear words such as … I think I will use strategies to …		5 min
1	**Warm up** Ss are asked these questions: Have you heard about green Chemistry? What do you know about it? Then, ss watch the video "What is Green Chemistry?" Ss answer these questions based on the video: What is the importance of Green Chemistry? What key word or words helped you to infer that general idea?		Yes, I have. No, I haven't. I know that green chemistry is… Green chemistry is important because… I heard the word(s)…	Schema Activation	5 min
2	**Pre-Task 1** Ss are asked: **M1:** Do you know the 12 principles of Green Chemistry? Ss match principles of green chemistry with their descriptions. Half of the class has the concepts and the other half has the descriptions. Each st looks for the correct matching. Ss are asked: How did you two realize that you matched?	W S L S	Do you have a concept or a description? I have a concept. I have a description. My concept is… This description is about… I think we match. We don't match! We noticed that... We saw this word.	Matching	10 min

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
3	**Pre-Task 2** **H1:** Ss watch the video "How to Improve your Listening Skills," and write down the 4 tips that the speaker gives to improve the listening skill. Ss compare their answers with a partner. Then, general checking as a class. As a class, ss comment on the ones that are useful for a conference.	L W R S	Tip __ is to… I think that tip __ is …	Listening to specific information	5 min 5 min
4	**Pre-Task 3** **H2:** Ss read synonyms and definitions of 8 words to complete sentences. As a class, ss read their statements loudly to compare to others.	R W S	<u>Vocabulary</u> Bias - frightening – coalesce - brace – triggering - randomness – aesthetic - biomimicry	Word Learning	10 min
5	**Main Task** **H3:** Ss watch the video "Intellectual Ecology, Green Chemistry" to complete a table with the main ideas of the video by answering 5 questions. In pais, ss compare their answers. Some ss are nominated to read their answers for a general check.	L W R S			50 min
6	**Post-Task** **H4**: Ss read an excerpt from the previous video and write the main idea. Ss read their main ideas. Ss highlight the sentence that was key to come up with the main idea.	R W S	<u>Vocabulary</u> Strength – Fuzzy – Embrace – Downstream	Identifying main ideas	10 min
Ss work on their portfolios					10 min

Lesson Plan

Unit 1: Listening to Chemists **Lesson 2**

Course: Chemming Words **Instructor:** Erick Oses Ilama **Date:** August 29, 2018

Unit Goal: By the end of the unit, the students will be able to demonstrate comprehension of academic chemistry-related audio clips, presentations, and speeches by analyzing meaning and structures.

General Objective: By the end of the lesson, students will be able to effectively identify the supporting details in an academic speech related to chemistry by taking notes and filling in graphic organizers.

Specific objectives: At the end of the lesson, students will be able to

1. properly explain the chemical reaction when opening a can of soda and tasting it by orally describing those facts.
2. successfully demonstrate understanding of key vocabulary by completing sentences.
3. correctly demonstrate the capacity to identify main ideas from a video clip by writing them down.
4. successfully identify supporting details from a video clip by answering questions in written and oral form.
5. properly mention the main ideas and supporting details of a video about enzymes and catalysis by presenting them orally.
6. correctly show understanding of adverbs ending in -ly by forming, using, and identifying them.

Abbreviations: T=Teacher, Ss=Students, St=Student, H=Handout, =Listening, R=Reading, S=Speaking, W=Writing, M=Materials

Materials:

Video 1: "Introduction to enzymes and catalysis" Taken from https://www.youtube.com/watch?v=G7ZAwUdBNFE

M2: Words

M3: Questions

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
	Last class review Ss see a slide show. Ss recall key words from pictures and questions. 9 words are targeted.	S	Green chemistry – biomimicry – set out – randomness – coalesce — aesthetic – feedstocks - stoichiometry – frightening	Recalling words	10 min
	Opening Ss are told that the topic of the lesson is Enzymes and Catalysis, and the objective of the lesson is to extract details from a speech. Ss work on their portfolio. Then, ss share their predictions orally.	W-S	I think I will learn about… I think I will hear words such as … I think I will use strategies to …	Predicting	5 min
1	**Warm up** Ss see a can of soda. T asks: how do you call this in English? Ss answer. T shows a picture with a bunch of cans. Ss learn that a bunch of is synonym of a group of. Ss see pictures of beverages as well. One st opens the can of soda. T asks: what is that sound? Could you explain? Ss try to answer. Ss drink a sip of soda, and try to describe what they feel in their tongue from the chemistry point of view.	S	A bunch of molecules Beverages That sound is… I think there is a reaction because...	Schema Activation Describing sensations	10 min
2	**Pre-Task 1** **H5-H6-H7:** In groups of 3, Ss work with vocabulary necessary to accomplish the main task. **M 2**: To get the words in handout 8, ss need to walk around the classroom because the concepts and definitions are on the walls. Ss read the sentences. T checks pronunciation and gives feedback.		pump – fizz- dissociate – tautomerize – polymerize - keto-enol - cation – decarboxylation – anhydrase – covalence - collide	Recognizing grammatical word classes	20 min

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
2	**Pre-Task 2** **M3:** Ss play a game. One st reads a definition that takes from a bag, and the classmates try to recall the word. Correct word and pronunciation are necessary to score. The st or ss who win receive a prize.	S	pump – fizz- dissociate – tautomerise – polymerase - keto-enol - cation – decarboxylation – anhydrase – covalence - collide		10 min
3	**Pre task 3** **H 8:** Ss watch the video "Introduction to enzymes and catalysis." Ss write down the main ideas of the video. In pairs, ss compare their main ideas. T calls on different ss to read the main ideas.	L W S	I think that main idea ___ is about…	Listening to specific information	15 min
4	**Main Task 1** **H9:** Ss watch the video "Introduction to enzymes and catalysis." Ss write down the supporting details by answering questions. Ss compare their answers with a classmate. T calls on different ss to read the main ideas.	L W S	The answer is… I have… I understood that…		20 min 10 min
5	**Main Task 2** Ss choose a paper with a number. Numbers are form 1 to 5. Each number represents one main idea from the video. Ss rehearse the main idea and the supporting details. Then Ss present a short speech explaining the main idea.	R S	Good evening. I am going to speak about… Thank you.		25 min

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
6	**Post-Task** **H10**: Ss learn that some adverbs are formed by adding –ly to an adjective. Ss follow to rule with 3 adjectives to form adverbs. Then, ss complete 3 sentences using the adverbs they just write. Later, ss listen to a part of the video "Introduction to enzymes and catalysis" to complete a passage with the adverbs they hear.	W L	The adverb is …	Creating ly-adverbs	10 min
Ss work on their portfolios					10 min

Lesson Plan

Unit 1: Listening to Chemists **Lesson 3**

Course: Chemming Words **Instructor:** Erick Oses Ilama **Date:** September 5, 2018

Unit Goal: By the end of the unit, the students will be able to demonstrate comprehension of academic chemistry-related audio clips, presentations, and speeches by analyzing meaning and structures.

General Objective: By the end of the lesson, students will be able to adequately identify connectors in a speech by analyzing a video clip.

Specific objectives: At the end of the lesson, students will be able to

1. correctly describe the concept of covalent bond by explaining a meme and a comic strip.

2. achieve oral communication successfully by organizing, rehearsing, and performing a play to illustrate the concept of covalent bonding.

3. successfully demonstrate understanding of key vocabulary by matching definitions with pictures and completing sentences.

4. correctly identify the connectors used in a video clip by filling in the blanks of three excerpts.

5. properly show understanding of the use of four kinds of connectors by completing sentences.

6. correctly show understanding of the use of four kinds of connectors by modifying two passages using different connectors.

Abbreviations: T=Teacher, Ss=Students, St=Student, H=Handout, =Listening, R=Reading, S=Speaking, W=Writing, M=Materials

Materials:

Video 1: "Introduction to enzymes and catalysis?" taken from: https://www.youtube.com/watch?v=G7ZAwUdBNFE

M4: Connectors

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
	Last class review Ss see a slide show. Ss recall key words from pictures and questions. 11 words are targeted.	S	pump – fizz – dissociate – tautomerize – collide – polymerize - keto-enol – cation – decarboxylation - anhydrase - covalence	Recalling words	10 min
	Opening Ss are told that the topic of the lesson is Covalent Bonds, and the objective of the lesson is to identify connectors in a speech. Ss work on their portfolio. Then, ss share their predictions orally.	W S	I think I will learn about… I think I will hear words such as … I think I will use strategies to …	Predicting	5 min
1	**Warm up** Ss watch a meme about a covalent joke. Ss explain the meme. Ss watch a comic strip. Silently, they read the dialogue. Then, men and women read their parts loudly. T asks; what is this comic strip about? Ss answer. Ss are asked; what are covalent bonds? Ss answer. T elicits more information by asking; Can all the elements bond covalently? What else do you remember about covalent bonding?	S R S S	The meme is about… The joke is that … I only have 17 electrons. I have one extra one. I am positive.	Describing a meme Schema Activation	5 min
2	**Pre-Task 1** Ss perform a play to exemplify the concept of covalent bond. Ss are divided into 2 groups. Each group represents an atom. Some students are the nucleus, others are the protons, and others are the electrons. Then, electrons are shared. One st describes the bonding while the others perform.	S	Let's be an atom of… I want to be an electron. I can be a proton. We can be the nucleus.		10 min

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
3	**Pre-Task 2**				
	H11: Ss work out vocabulary necessary to succeed the main task (1 verb and 5 nouns) by reading definitions and matching some of them with pictures. Then, T calls on some students to say their matchings.	R S	Swap – Shell – Allotrope – Fullerene – Halide - Lattice		7.5 min
	H12: Ss complete 5 sentences using words previously worked out. Then, T calls on some students to read the sentences loudly. T checks and corrects possible pronunciation mistakes.	W S	In number ___, I wrote Number __ is		7.5 min
4	**Main Task 1**				
	H13-H14-H15: Ss are divided in 3 groups. Each group receives a different handout. Each group listens to a part of the video "What Are Covalent Bonds?" to complete a passage by filling in the blanks. Then, in each group, ss compare their words. Ss receive 2 more handouts. To complete the missing information, each st works with one classmate of the other groups.	L S	What word do you have in number __? In blank X, I wrote… Word number ___ is…	Negotiating meaning	15 min 10 min
5	**Main Task 2**		Here we have the post we need.	Negotiating meaning	15 min
	H16-M4: Ss are divided into 2 groups. Each group looks for 2 posts that have connectors that they need to complete some sentences. Members of each group compare their findings.	W S	I am going to use this connector.		
	Ss of each group look for a partner from the other group to complete their sentences.	S	What do you have in this one? What is another word that I can use here?		

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
6	**Post Task** **H17:** Ss work individually to create their own version of 2 passages by using connectors to fill in the blanks. Then, ss work in pairs to compare their versions. Each st reads one of the passages to the other classmate. Some ss are required to read the passages loudly.	W S	**Connectors to give a reason or cause** As / Since / Seeing that **Connectors to add information** Moreover / Furthermore / In addition **Connectors to show contrast** However / Nevertheless / On the contrary **Connectors to show consequence** Consequently / As a consequence / As a result / Therefore	Personalizing a passage	15 min 10 min
Ss work on their portfolios					10 min

Lesson Plan

Unit 1: Listening to Chemists **Assessment Lesson**

Course: Chemming Words **Instructor:** Erick Oses Ilama **Date:** September 12, 2018

Unit Goal: By the end of the unit, the students will be able to demonstrate comprehension of academic chemistry-related audio clips, presentations, and speeches by analyzing meaning and structures.

General Objective: By the end of the lesson, students will be able to successfully identify the main idea and specific details of a video clip as a source of information in order to prepare and present a short speech.

Specific objectives: At the end of the lesson, students will be able to

1. correctly give an opinion about a popular saying by expressing the meaning of it.
2. successfully identify the main idea and specific details of a video clip by activating schema of previous classes.
3. successfully demonstrate understanding of key vocabulary by completing sentences.
4. correctly identify the main idea and specific details from of a video clip by filling in the blanks and answering questions.
5. appropriately give a speech by providing the main idea and specific details about the acidification of the oceans.

Abbreviations: T=Teacher, Ss=Students, St=Student, H=Handout, =Listening, R=Reading, S=Speaking, W=Writing, M=Materials

Materials:

Video 1: "Coral Reefs 101." Taken from: https://www.youtube.com/watch?v=ZiULxLLP32s

Video 2: "Ocean Acidification." Taken from: https://www.youtube.com/watch?v=fgBozLCGUHY

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
	Last class review Ss see a slideshow. Ss recall key words from pictures and questions. 6 words are targeted.	S L	Swap – Shell – Allotrope – Fullerene – Halide – Lattice	Recalling words	10 min
1	**Warm up** Ss see a picture of clouds. Ss say what they see. Another picture is shown. The picture has the phrase Every dark cloud has a silver lining. Ss are asked if they know the meaning of the phrase. Ss try to infer the meaning. T helps and/or clarifies the meaning.	S	I see… I think the meaning of the saying is… I would also say that…	Giving an opinion	5 min
2	**Pre-Task 1** Ss watch a picture of a coral reef. Ss say what they see. T elicits information by asking; Does Costa Rica have coral reefs? What do you know about coral reefs?	S	That picture is about… I see.. I don't know how to say that in English. Yes, it does. I know that coral reefs…	Answering a question	5 min
	H18: Ss listen to an audio about coral reefs, and identify the main ideas and supporting details. Ss listen to the audio 2 times. If ss struggle a lot, they watch the video, which has some written information. Ss work in pairs to compare their answers. T calls on nominated students to read one answer loudly.	L S	What do you have in question X? I think the answer is… In number X, I wrote…	Paying attention to the speaker Answering a question	15 min

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
3	**Pre-Task 2** **H19:** Ss learn vocabulary necessary to successfully do the main task by reading definitions and completing 4 sentences. Ss work in pairs to compare their completions. T calls on some students to read the sentences.	R W S	Acidic - Made up of – Shell - A double whammy - Silver lining	Asking questions and sharing information	15 min
4	**Main Task** **H20:** Ss were invited to a conference to explain what the acidification of the oceans is. Individually, ss listen to an audio about coral reefs. Ss fill in blanks, select a choice, and answer questions to identify the topic, the main idea, and specific details in order to prepare a short speech. **H21:** From H 20, ss select 5 pieces of information to prepare a speech.	L		Listening attentively	20 min 5 min
5	**Post-Task** Ss rehearse their speeches, and present them in front of their classmates.	W R S	Good evening. I am going to speak about… To start my presentation, I have to say that… I can also tell you that… Moreover, … In addition,… Finally, the solution is to… Thanks for your attention, and have a good night.	Reading and Looking-up	15 min
Ss are required to record 25 words as part of the data collection.					20 min

Lesson Plan

Unit 2: Asking for Chemistry Information **Lesson 1**

Course: Chemming Words **Instructor:** Erick Oses Ilama **Date:** September 19, 2018

Unit Goal: By the end of the unit, the students will be able to interact with members of the science community in a formal conference setting regarding chemistry-related topics with intelligibility and comprehensibility.

General Objective: By the end of the lesson, students will be able to appropriately request information from a speaker by asking specific direct questions about a topic presented at a conference.

Specific objectives: At the end of the lesson, students will be able to

1. correctly identify the importance of asking information questions by orally restating the purpose of a video clip.
2. successfully identify the three states of matter by watching a song video and completing a graphic organizer.
3. effectively identify a definition of matter by watching a video and completing sentences.
4. properly write information questions based on a text related to matter by using the prompts given.
5. successfully ask information questions by participating in a round-table setting.
6. properly show understanding of the auxiliary verbs is, are, do, and does by completing information questions.

Abbreviations: T=Teacher, Ss=Students, St=Student, H=Handout, =Listening, R=Reading, S=Speaking, W=Writing, M=Materials

Materials:

Video1: "The importance of asking good questions." Taken from: https://www.youtube.com/watch?v=kFVcpzSHuDw

Video 2: Song "Matter Chatter" Taken from: https://www.youtube.com/watch?v=C33WdI64FiY

Video 3: "What's Matter?" - Crash Course Kids #3.1 Taken from: https://www.youtube.com/watch?v=ELchwUIlWa8

M5: Information about Physical Properties of Matter. Taken from: https://www.thoughtco.com/physical-properties-of-matter-608343

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
	Opening Ss are told that the topic of the lesson is Matter and the objective of the lesson is to ask information questions. Ss work on their portfolio. Then, ss share their predictions orally.	W S	I think I will learn about… I think I will hear words such as … I think I will use strategies to …	Predicting	10 min
1	**Warm up** Ss watch the video "The importance of asking good questions." In pairs, ss orally practice asking wh questions about chemistry topics such as an element, molecules, biochemistry, green chemistry, covalent bond, a reaction, stoichiometry, catalysis, carbon allotropes.	L S	What Why How Where When	Asking questions	5 min
2	**Pre-Task 1** **H22:** Ss watch the song video "Matter Chatter" to complete a graphic organizer. Ss ask questions regarding matter using the graphic organizer.	L S	What are… 1. the three states of matter 2. characteristics of solids 3. examples of solids 4.characteristics of liquids 5. examples of liquids 6. characteristics of gases 7. examples of gases 8. other ways to classify matter?	Asking questions	15 min

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
	Pre-Task 2				
3	**H23:** Ss complete 4 sentences by joining phrases from a box. Ss share their sentences in pairs. T calls on ss to read their sentences. Ss watch the video "What's Matter?" and comment on it.	W S L-S	Weight - Weigh - Take up - Matter – Weight – Volume What did you write in sentence X? I wrote…	Asking questions	15 min
	Main Task				
4	**Planning and Rehearsing**				
	H24: Ss receive a text, and they write wh-questions about the topics in the text using the prompts given. Individually, ss rehearse the questions	W S	What is / are What does / do Why matter is…	Writing questions	20 min
5	**Reporting**		How is / are		
	M5: Ss are organized in a round-table formation. One st opens the meeting by introducing the topic of matter. Each st asks the previous questions of a classmate who has the answers in a piece of paper. Each st takes turns to ask questions.	S	When do	Asking questions	30 min
6	**Post Task**				
	H25: Individually, ss read brief explanations about the auxiliary verbs is, are, do, and does. Then, ss complete sentences using those auxiliaries. T explains that wh-questions have a falling intonation. Ss work in pairs to compare answers. T calls on ss to read the questions.	R W S	Is, are, do, does	Falling intonation	20 min
Ss work on their portfolios					10 min

Lesson Plan

Unit 2: Asking for Chemistry Information **Lesson 2**

Course: Chemming Words **Instructor:** Erick Oses Ilama **Date:** September 26, 2018

Unit Goal: By the end of the unit, the students will be able to interact with members of the science community in a formal conference setting regarding chemistry-related topics with intelligibility and comprehensibility.

General Objective: By the end of the lesson, students will be able to appropriately request information from a speaker by asking specific indirect questions about a topic presented at a conference.

Specific objectives: At the end of the lesson, students will be able to

1. successfully identify the importance of being polite by completing a graphic organizer with information from a video clip.

2. correctly identify introductory phrases to ask indirect questions by completing a graphic organizer with information from a video.

3. properly identify the name of 10 chemical elements by completing a graphic organizer with information from a video clip.

4. correctly write down indirect questions about chemical elements by using the prompts given and a text.

5. properly ask indirect questions about chemical elements by participating in a simulated conference.

6. accurately show understanding of the word order in indirect questions by transforming direct questions into indirect ones.

Abbreviations: T=Teacher, Ss=Students, St=Student, H=Handout, =Listening, R=Reading, S=Speaking, W=Writing, M=Materials

Materials:

Video 1: "How to Be Polite in English" Taken from: https://www.youtube.com/watch?v=NnRwM5Kv5bE
Video 2: "Indirect Questions" Taken from: https://www.youtube.com/watch?v=xugWC34kDzs
Video 3: "10 Strangest Elements" Taken from: https://www.youtube.com/watch?v=DbszbueKlgE
M6: Materials Excerpts from the video "10 Strangest Elements"

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
	Last class review Ss see a slide show. Ss recall key words from pictures and questions. 10 words are targeted.	S	solid – liquid - gas -weight - weigh - matter - volume - isotropic - anisotropic - sample	Recalling words	10 min
	Opening Ss are told that the topic of the lesson is Strangest Elements, and the objective of the lesson is to ask indirect questions. Ss work on their portfolio. Then, ss share their predictions orally.	W S	I think I will learn about… I think I will hear words such as … I think I will use strategies to …	Predicting	5 min
1	**Warm up** **H26:** Ss watch the video "How to Be Polite in English," and individually write down the 5 forms to be polite in English. Ss comment on the importance of being polite and give examples of situations to be polite.	L W S	Polite	Being polite	5 min
2	**Pre-Task 1** **H27:** Ss watch the video "Indirect Questions" and complete a graphic organizer. Ss ask questions regarding properties of matter or elements using the graphic organizer.	L W S	Could you tell me…. Do you know… Do you have any idea… I would like to know…	Asking indirect questions	10 min

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
	Main -Task		lutetium - technetium - silicon	Paying	
3	**H28:** Part 1. Ss watch the video "10 Strangest Elements" and complete a graphic organizer.	L W	- gallium - francium - curium - antimony - bismuth - elements	attention to specific	10 min
4	Part 2. Individually, ss focus on one element and write down indirect questions.		112 through 118 - carbon	information	
					15 min
	Rehearsing		Could you tell me….		
	Ss rehearse the questions that they wrote in H28.	R	Do you know…		
	Then, each st receives information about one strange element different from the one in H 28.	S	Do you have any idea… I would like to know…		
	Each st reads the information to realize the underlined sentences.				
				Asking indirect	25 min
5	**Performing**			questions	
	M6: Simulating a conference setting, each st comes to the front of the class, and presents the element he or she has. Since one st of the audience had written down indirect questions about that element, that st asks indirect questions about that element and the presenter answers.	S L			
6	**Post-Task**				
	H29: Individually, ss read brief explanations about the auxiliary verbs is, are, do, and does. Then, ss complete sentences using those auxiliaries. T explains that wh-questions have a falling intonation. Ss work in pairs to compare answers. T calls on ss to read the questions.	R W S L			10 min
Ss work on their portfolios					10 min

Lesson Plan

Unit 2: Asking for Chemistry Information **Lesson 3**

Course: Chemming Words **Instructor:** Erick Oses Ilama **Date:** October 3, 2018

Unit Goal: By the end of the unit, the students will be able to interact with members of the science community in a formal conference setting regarding chemistry-related topics with intelligibility and comprehensibility.

General Objective: By the end of the lesson, students will be able to adequately clarify concepts by repeating, restating, and summarizing ideas.

Specific objectives: At the end of the lesson, students will be able to

1. successfully show understanding of examples of alkanes and alkenes by orally sharing information.
2. correctly identify the importance of summarizing and steps to do it by writing them down.
3. properly identify the definition of paraphrasing and steps to do it by writing them down.
4. successfully collect information about functional groups by answering questions and completing a graphic organizer.
5. correctly present a speech about examples of alkanes and alkenes by summarizing and paraphrasing information.
6. adequately derive words by adding the suffixes -ane, -ene, -ol, and -ic to roots.

Abbreviations: T=Teacher, Ss=Students, St=Student, H=Handout, =Listening, R=Reading, S=Speaking, W=Writing, M=Materials

Materials:

Video 1: "The Simple Summary" Taken from: https://www.youtube.com/watch?v=V-ki6TP4EYs
Video 2: "Paraphrasing: The Basic Steps" Taken from: https://www.youtube.com/watch?v=nSGzuxbdheI
Video 3: "The functional group concept explained" Taken from: https://www.youtube.com/watch?v=nMTQKBn2Iss
M7: Texts about alkanes and alkenes. Taken from: https://www.britannica.com/science/

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
	Last class review Ss see a slide show. Ss recall key words from pictures and questions. 8 words are targeted.	S	lutetium - technetium - silicon - gallium - francium - curium - antimony - bismuth	Recalling words	10 min
1	**Opening** Ss are told that the topic of the lesson is Functional Groups, and the objective of the lesson is to clarify concepts by repeating, restating, and summarizing ideas. Ss work on their portfolio. Then, ss share their predictions orally.	W S	I think I will learn about… I think I will hear words such as … I think I will use strategies to …	Predicting	5 min
2	**Warm up** **M7:** Ss read a piece of paper about examples of alkanes and alkenes. In pairs, ss share the information they just read.	R S	Methane – Ethane – Propane - Butane – Ethene – Propene - Butene	Activating Schema	5 min
3	**Pre-Task 1** **H30:** Ss watch the video "The Simple Summary," and individually answer 2 questions and write down 6 steps to summarize. Then, in pairs, they compare answers. There is a general check.	L W S		Summarizing	15 min
	Pre-Task 2 **H31:** Ss watch the video "Paraphrasing: The Basic Steps" and answer 1 question and complete 4 steps to paraphrase. Then, in pairs, they compare answers. There is a general check	L W S		Paraphrasing	15 min

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
	Pre-Task 3				
4	**H32:** Ss watch the video "The functional group concept explained," and individually answer 6 questions.	L W	carbon - compounds - hydrogen – methane - covalent bonds –		10 min
	H33: Ss complete a graphic organizer with examples of functional groups. Then, in 2 groups, they compare answers. There is a general check.	L W S	hydrocarbons – atoms – molecule - molecules – properties		10 min
5	**Main Task**		alkanes: methane – ethane – propane – butane		
	Planning: H34: Individually, ss summarize and paraphrase the material given in the warm-up section and information from the video "The functional group concept explained" to create a short speech. At least, ss have to present 6 ideas.	W	alkenes: ethene – propene – butane – alcohol: methanol – ethanol – propanol - butanol carboxylic acid: methanoic acid - ethanoic acid -	Summarizing and paraphrasing	10 min
	Practice: Ss rehearse their speech. Ss make sure they pronounce the words correctly. T assists ss.	S	propanoic acid - butanoic acid esters – ketones - amines		5 min
	Presentation: Ss take turns to perform their speeches in front of the class. T takes notes of possible mistakes. Then, T corrects possible oral mistakes.	S L		Reading and looking up	10 min
6	**Post Task**				
	H35: Ss form words by adding the suffixes -ane, -ene, -ol, and –ic to given roots. Then, ss compare with a partner.	W S			10 min
Ss work on their portfolios					10 min

Lesson Plan

Unit 2: Asking for Chemistry Information **Lesson 4**

Course: Chemming Words **Instructor:** Erick Oses Ilama **Date:** October 10, 2018

Unit Goal: By the end of the unit, the students will be able to interact with members of the science community in a formal conference setting regarding chemistry-related topics with intelligibility and comprehensibility.

General Objective: By the end of the lesson, students will be able to correctly interact with participants at a conference by asking for and stating an opinion about chemical reactions.

Specific objectives: At the end of the lesson, students will be able to

1. properly describe chemical reactions between alkali metals with water by describing images shown in a video clip.
2. successfully identify questions to ask for opinions by watching a video clip and making a list of them.
3. successfully identify introductory forms to give an opinion by watching a video clip and making a list of them.
4. effectively interact among chemists by asking and giving opinions about chemistry-related memes.
5. adequately interact with chemists by giving opinions about important chemical reactions.
6. correctly pronounce words related to chemistry by repeating words selected by the students from the lesson.

Abbreviations: T=Teacher, Ss=Students, St=Student, H=Handout, =Listening, R=Reading, S=Speaking, W=Writing, M=Materials

Materials:

Video 1: "Reaction of Francium (alkali metal) with water" Taken from: https://www.youtube.com/watch?v=eD9BiYvsT4k
Video 2: "How to Ask for Opinions in English: 5 Questions You Need to Know" Taken from: https://www.youtube.com/watch?v=Tx8pVIPyS6U
Video 3: "How to express your opinion in English" Taken from: https://www.youtube.com/watch?v=GnzXc66n0T0
Video 4: "6 Chemical Reactions That Changed History" Taken from: https://www.youtube.com/watch?v=jb4CMnT2-ao
M8: Memes
M9: Descriptions of important reactions: Excerpts taken from the video "6 Chemical Reactions That Changed History"

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
	Last class review Ss see a slideshow to recall key words about Functional Groups. 23 words are targeted.	S L	Alkanes (methane, ethane, propane, butane) alkenes (methene, ethene, propene, butane) Alcohol (methanol ,ethanol, propanol, butanol) carboxylic acid (methanoic, ethanoic, propanoic, butanoic acid) esters – ketones - amines	Recalling words	10 min
	Opening Ss are told that the topic of the lesson is Important Reactions, and the objective of the lesson is to ask for and give opinions. Ss work on their portfolio. Then, ss share their predictions orally.	W S	I think I will learn about… I think I will hear words such as … I think I will use strategies to …	Predicting	5 min
1	**Warm up** Ss watch the video "Reaction of Francium (alkali metal) with water," and ss describe or predict what is happening in the video because the video is silent.	S	I see that … When mix X and X, they will react and the consequences are that… I think that the 2 substances will…	Activating schema about chemical reactions	5 min
2	**Pre-Task 1** **H36:** Ss watch the video "How to Ask for Opinions in English: 5 Questions You Need to Know" to make a list of 5 questions to ask for an opinion. Then, in pairs, ss use the questions to ask for opinions to get information about the last chemistry laboratory class that they took.	S L	What is your opinion on …? What are your thoughts on…? What do you think about…? What's your take on…? What are your initial thoughts on…?	Asking for opinions	15 min

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
3	**Pre-Task 2** **H36:** Ss watch the video "How to express your opinion in English" to make a list of 12 phrases to introduce an opinion. Then, in pairs, ss can share their opinions about the last chemistry laboratory class that they took.	L W S	I think… I believe… I feel… I suppose… I guess… In my opinion, In my view, From my viewpoint, From my point of view, From my perspective, According to me, It seems to me that…	Giving an opinion	20 min
4	**Pre-Task 3** **M8:** In pairs, ss are given a meme, and they ask questions to know his/her classmate's opinion about the meme.	S	I think this meme is… because it means that… I don't like this meme because it… Honestly, I don't understand this meme because…	Asking for opinions Giving an opinion	5 min
5	**Main Task** Ss watch the video "6 Chemical Reactions That Changed History" to make a list of those reactions. Ss share their opinions about the video.	L W S	In my opinion, this video is … because it…		10 min
	Preparing: **M9:** Each st reads the script from the video about one chemical reaction, and ss give their opinions about the reaction they are in charge of.	R S L			5 min 20 min
	Presenting: Ss sit in a round-table formation to share their opinions. Then, ss decide which reaction might be considered the one with the highest impact on the humanity.			Giving an opinion. Reading-and-looking-up	

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
6	**Post-Task** **H37:** Each s selects 3 chemistry- related words from the scripts. Then, each st writes the words on the board for the classmates to complete a list of 18 words. Pronunciation is then practiced.	R W S		Pronouncing	10 min
Ss work on their portfolios					10 min

Lesson Plan

Unit 2: Asking for Chemistry Information **Assessment Lesson**

Course: Chemming Words **Instructor:** Erick Oses Ilama **Date:** October 17, 2018

Unit Goal: By the end of the unit, the students will be able to interact with members of the science community in a formal conference setting regarding chemistry-related topics with intelligibility and comprehensibility.

General Objective: By the end of the lesson, students will be able to correctly interact with participants at a conference by asking direct and indirect questions, summarizing and restating information, and asking for and giving an opinion about the hydrophobic effect.

Specific objectives: At the end of the lesson, students will be able to

1. correctly identify three applications of hydrophobic surfaces by watching a video and making a list of them.

2. properly show understanding of asking questions, summarizing and paraphrasing information, and giving an opinion by practicing them with a text about wettability.

3. successfully interact with members of the scientific community by asking questions, summarizing and paraphrasing information, and giving an opinion about the hydrophobic effect.

4. successfully summarize and give an opinion about hydrophobic materials by presenting them orally in a conference setting.

Abbreviations: T=Teacher, Ss=Students, St=Student, H=Handout, =Listening, R=Reading, S=Speaking, W=Writing, M=Materials

Materials:

Video 1: “Hydrophobic Surfaces” Taken from: https://www.youtube.com/watch?v=HP5dDJGz8b4

Video 2: “The Hydrophobic Effect” Taken from: https://www.youtube.com/watch?v=pibd1LiNdVI

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
	Last class review Ss see a slideshow. Ss recall key words from pictures and questions. 12 words are targeted.	S L	process - nitrate - compound - alloy - saponify - formula - alkali - triglyceride - polar - bronze - copper - reaction -	Recalling words	10 min
1	**Warm up** Ss watch a picture of a lotus plant and a picture of foul meaning mud. Ss are told the lotus leaves have hydrophobic properties. **H38:** Ss label the lotus flower and the leaf. Ss watch the video "Hydrophobic Surfaces" to identify applications of hydrophobic surfaces.	W L S	Lotus, leaf (leaves), foul	Activating schemata	15 min
2	**Pre-Task** **H39:** Ss review the 4 classes of Unit 2 by writing direct and indirect questions, summarizing and rephrasing the text, and giving their opinions about a text named Wettability.	R S	Direct and indirect questions, summarizing and rephrasing, asking for and giving opinions	Recalling and practicing previous lessons	30 min
3	**Main Task** **H40:** Ss watch the video "The Hydrophobic Effect" to ask direct and indirect questions. Ss use this video and the previous one to summarize and paraphrase the information.	W	Direct and indirect questions, summarizing and rephrasing, asking for and giving opinions	Asking direct and indirect questions.	45 min
4	**Post-Task** Orally, ss share their summary and opinions about the topic in the videos.	S		Summarizing. Giving an opinion.	10 min

Lesson Plan

Unit 3: Interacting with Chemists **Lesson 1**

Course: Chemming Words **Instructor:** Erick Oses Ilama **Date:** October 24, 2018

Unit Goal: By the end of the unit, the students will be able to deliver effective speeches about chemistry to an audience of chemistry students, chemists, and stakeholders by communicating information in a clearly and concisely manner.

General Objective: By the end of the lesson, students will be able to appropriately deliver a short speech by conveying the global idea and supporting details in an academic manner.

Specific objectives: At the end of the lesson, students will be able to:

1. correctly identify properties of titanium by saying why this chemical element is used as a metaphor in a song.

2. successfully identify tips about public speaking by writing them down in a list.

3. successfully identify properties and specific details of titanium by completing a graphic organizer while watching a video clip.

4. accurately identify details about titanium and titanium dioxide expressed in a video by completing a graphic organizer.

5. correctly present facts about titanium by giving a 3-minute speech in a simulated international chemistry conference.

6. accurately show understanding of conditionals type1 to express possible events and their consequences about titanium and its applications by combining sentences.

Abbreviations: T=Teacher, Ss=Students, St=Student, H=Handout, =Listening, R=Reading, S=Speaking, W=Writing, M=Materials

Materials:

Video 1: How to Give a Speech. Taken from: https://www.youtube.com/watch?v=TE4LfXGRRr0
Video 2: Titanium song. Taken from: https://www.youtube.com/watch?v=9aQJBZibbL4
Video 3: Titanium Element. Taken from: https://www.youtube.com/watch?v=2nQriFkcA-Y
Video 4: Titanium: Periodic table of Videos. Taken from: https://www.youtube.com/watch?v=MpFTQYynrc4

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
	Opening Ss are told that the topic of the lesson is Titanium, and the objective of the lesson is to deliver a short speech by presenting the global idea and supporting details in an academic manner. Ss work on their portfolio. Then, ss share their predictions orally.	S L	I think I will learn about… I think I will hear words such as … I think I will use strategies to …	Predicting	10 min
1	**Warm up** Ss watch the song video "Titanium" by Sia. T elicits information from ss by asking: What chemical element does the song mention? What do you know about this element? How is titanium related to the song?	L S	The song mentions… Titanium is… Titanium means… and the song is… <u>Vocabulary:</u> bullets – ricochet – aim – sticks and stones	Activating schema about a chemical element	5 min
2	**Pre-Task 1** **H41:** Ss watch the video "How to Give a Speech" to make a list of 7 tips about public speaking.			Listening to specific information	10 min
3	**Pre-Task 2** **H42:** Ss watch the video "Titanium Element" to complete a graphic organizer with specific information about physical and chemical properties of titanium as well as uses and disadvantages of this element. In pairs, ss compare their answers.		Density – corrode – smooth – luster	Listening to specific information	15 min

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
4	**Pre-Task 3** **H43:** Ss watch the video "Titanium: Periodic table of Videos" to complete a graphic organizer to obtain more information about titanium and titanium dioxide. In pairs, ss compare their answers.		titanium tetrachloride - alloys	Identifying details	15 min
5	**Main Task** **Planning** Ss are supposed to be invited to conference to speak about titanium. Individually, ss choose information from the previous handouts to prepare a short speech. **Rehearsal:** Ss rehearse their speech. T helps out with pronunciation. **Presentation:** In a conference setting, ss present their speech. T takes notes of possible mistakes. **Feedback:** On the board, T writes down possible words that were not correctly pronounced as well as other language problems.	W S S		Reading and looking up	10 min 10 min 10 min
6	**Post-Task** **H44:** Ss read about conditional sentences type 1 formation. Then, ss practice by combining possible events and consequences about titanium and its applications.	R W S			
Ss work on their portfolios					10 min

Lesson Plan

Unit 3: Interacting with Chemists **Lesson 2**

Course: Chemming Words **Instructor:** Erick Oses Ilama **Date:** October 31, 2018

Unit Goal: By the end of the unit, the students will be able to deliver effective speeches about chemistry to an audience of chemistry students, chemists, and stakeholders by communicating information in a clearly and concisely manner.

General Objective: By the end of the lesson, students will be able to appropriately use discourse markers in a speech about elements of life by giving a speech.

Specific objectives: At the end of the lesson, students will be able to:

1. correctly identify theories of origin of life by matching the theory and its enunciation.
2. successfully identify body language tips by making a list of four of them.
3. correctly identify life chemical elements by making a list of them.
4. properly use discourse markers by completing passages about the elements of life.
5. effectively use public speaking tips and discourse markers by giving a short speech.
6. successfully show understanding of discourse markers by classifying them according to their purpose.

Abbreviations: T=Teacher, Ss=Students, St=Student, H=Handout, =Listening, R=Reading, S=Speaking, W=Writing, M=Materials

Materials:

Video 1. "Origin of life on earth - How Life started on earth." Taken from: https://www.youtube.com/watch?v=etAPY710JWM
Video 2. "4 essential body language tips from a world champion public speaker." Taken from: https://www.youtube.com/watch?v=ZK3jSXYBNak
Video 3. "What are CHNOPS? These Chemical Elements = 98% of Life." Taken from: https://www.youtube.com/watch?v=w90wFlR53VM

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
	Last class review Ss see a slideshow to recall key words about titanium. 7 words are targeted.	S L R	Titanium - ricochet – aim – smooth – luster – tetrachloride - malleable	Recalling words	5 min
	Opening Ss are told that the topic of the lesson is CHNOPS: Elements of Life, and the objective of the lesson is to use connectors in a speech. Ss work on their portfolio. Then, ss share their predictions orally.	W S	I think I will learn about… I think I will hear words such as … I think I will use strategies to …	Predicting	10 min
1	**Warm up** **H45:** Ss watch the video "Origin of life on earth" to match 3 theories about the origin of life and their descriptions. Ss given their opinion about the theory they agree the most with.	L S	Panspermia	Activating schema	10 min
2	**Pre-Task 1** **H46:** Ss watch the video "4 essential body language tips from a world champion public speaker" and make a list of them. In pairs, ss compare their answers.	L W		Listening to specific information	10 min
3	**Pre-Task 2** **H47:** Ss watch the video "What are CHNOPS?" to make a list of six chemical elements considered the elements of life. In pairs, ss compare their answers.	L W S		Listening to specific information	10 min

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
4	**Main Task** **Planning** **H48:** Each st receives a passage to complete with specific discourse markers. Ss are told that they were invited to a conference to speak about the origin of life from the Chemical Evolution Theory point of view. **Rehearsal:** Ss rehearse their speech. T helps out with pronunciation.	W S	Nonetheless - However - Moreover – Furthermore - Consequently - Therefore - Indeed - In fact - For instance - Likewise - Correspondingly		5 min 15 min
5	**Presentation:** In a conference setting, ss present their speech. T takes notes of possible mistakes. **Feedback:** On the board, T writes down possible words that were not correctly pronounced as well as other language problems.	S		Reading and looking up Opening the body	10 min 10 min
6	**Post-Task** **H49:** Ss read sentences which have discourse markers. Ss classify them according to their function. T calls on each st to read one sentence and classify the discourse marker.	R W S			10 min
Ss work on their portfolios					10 min

Lesson Plan

Unit 3: Interacting with Chemists **Lesson 3**

Course: Chemming Words **Instructor:** Erick Oses Ilama **Date:** November 7, 2018

Unit Goal: By the end of the unit, the students will be able to deliver effective speeches about chemistry to an audience of chemistry students, chemists, and stakeholders by communicating information in a clearly and concisely manner.

General Objective: By the end of the lesson, students will be able to accurately interact with member of an audience after presenting a chemistry-related topic by answering questions in a clear and concise manner.

Specific objectives: At the end of the lesson, students will be able to:

1. correctly identify key information from a document by highlighting it.

2. successfully identify some advice about eye contact by answering questions.

3. correctly identify tips about answering questions after a presentation by answering questions from a video.

4. successfully show understanding of an interview to one of the Chemistry Noble Prize Winners 2018 by matching questions and answers.

5. effectively interact with members of an audience using public speaking techniques by answering questions.

6. properly show understanding of information questions in simple past tense by completing questions with was or did.

Abbreviations: T=Teacher, Ss=Students, St=Student, H=Handout, =Listening, R=Reading, S=Speaking, W=Writing, M=Materials

Materials:

Video 1. "Public Speaking Eye Contact." Taken from: https://www.youtube.com/watch?v=bHblBfPy5qU
Video 2. "How to Handle Questions from Audience." Taken from: https://www.youtube.com/watch?v=ha1efqW-4h0
Video 3. "Professor Frances Arnold (EuChemS2018 plenary speaker)." Taken from: https://www.youtube.com/watch?v=1645d8kcJLE
M10: Nobel Prize Press Release
M11: Questions

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
	Last class review Ss see a slideshow to recall key words about elements of life. 12 words are targeted.	S R	nitrogenous – rungs – oxidizing – antioxidant – phosphate - phosphorylation – dephosphorylation – sulfur – cysteine – methionine – disulfide - selenium	Recalling words	5 min 10 min
	Opening Ss are told that the topic of the lesson is Female Chemistry Noble Prize Winners, and the objective of the lesson is to answer questions after a presentation. Ss work on their portfolio. Then, ss share their predictions orally.	W S	I think I will learn about… I think I will hear words such as … I think I will use strategies to …	Predicting	
1	**Warm up** **M10:** Ss receive The Nobel Prize in Chemistry 2018 press release document, and they read it to underline who the winners are, the prize motivation, and the importance of Frances H. Arnold's work.	R S		Activating schema	10 min
2	**Pre-Task 1** **H50:** Ss watch the video "Public Speaking Eye Contact" and answer 3 questions. In pairs, ss compare their answers.	L W S		Listening to specific information	10 min
3	**Pre-Task 2** **H51:** Ss watch the video "How to Handle Questions from Audience" to answer some questions. In pairs, ss compare their answers.	L W S		Listening to specific information	10 min

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
4	**Pre-Task 3**				
	H52: In pairs, ss match some questions with their answers. Then, ss wacth the video "Professor Frances Arnold" to check their matching.	R S W L			10 min
5	**Main Task**				
	Planning		<u>Vocabulary:</u>		5 min
	M11: Each st receives a text about one of the 5 women who have won the Noble Prize in Chemistry. Ss are told that they were invited to a conference to speak about the work of these women.	S	radioactivity - pitchblende - uranium – polonium – radium – crystallography – enzyme – catalyst-		
	Rehearsal:				10 min
	Ss rehearse their speech. T helps out with pronunciation.	S			
	Presentation:			Public Speaking Eye contacting	20 min
	In a conference setting, ss present their speech. Classmates function as members of the audience.	S			
	After each presentation, classmates ask the questions that have been given. Each presenter will answer 4 questions about his or her laureate.				5 min
	Feedback: On the board, T writes down possible words that were not correctly pronounced as well as other language problems.				10 min
6	**Post-Task**		Was-did		
	H53: Ss read information about the simple past tense to complete information questions with was or did. In pairs, ss compare their questions.				
Ss work on their portfolios					10 min

Lesson Plan

Unit 3: Asking for Chemistry Information **Assessment Lesson**

Course: Chemming Words **Instructor:** Erick Oses Ilama **Date:** November 14, 2018

Unit Goal: Unit Goal: By the end of the unit, the students will be able to deliver effective speeches about chemistry to an audience of chemistry students, chemists, and stakeholders by communicating information in a clear and concise manner.

General Objective: By the end of the lesson, students will be able to appropriately deliver a short speech by conveying the global idea and supporting details in an academic manner.

Specific objectives: At the end of the lesson, students will be able to

1. effectively identify the importance of the Maillard reaction by matching information about it while watching a video.
2. correctly identify the context where the Millard reaction takes place by watching a video and filling in blanks.
3. successfully show understanding of key vocabulary by matching concepts and their definitions.
4. correctly explain the Maillard reaction by giving a short speech about it.
5. properly identify the correct pronunciation of some chemistry related words by pairing each word with its pronunciation.

Abbreviations: T=Teacher, Ss=Students, St=Student, H=Handout, =Listening, R=Reading, S=Speaking, W=Writing, M=Materials

Materials:

Video 1. "What is the Maillard Reaction?" Taken from: https://www.youtube.com/watch?v=c7WI41huAok

Video 2. "Browning Reactions in Foods Animation." Taken from: https://www.youtube.com/watch?v=gk_rPkglyao

M13: Maillard Reaction

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
	Last Class Review Ss see a slideshow. Ss recall key words from pictures and questions. 8 words are targeted.	S L	radioactivity - pitchblende - uranium – polonium – radium – crystallography – enzyme – catalyst	Recalling	10 min
1	**Warm up** **H54**: Ss watch the video "What is the Maillard Reaction?" to match information presented in to columns by writing numbers in parenthesis. T nominates students to read their matching.	L W S	Maillard reaction - Thiophenes – Oxazoles - Alapyridaine	Activating schema	5 min
2	**Pre-Task 1** **H55:** Ss watch the video "Browning Reactions in Foods Animation" to complete a summary of browning reactions. Ss filling in blanks. In pairs, ss compare their completion.	L R W S	Phenolic – Polyphenol - Carmelization - carbonyl group – Glucose – Lysine – Dehydrate - Polymerize	Listening to specific information	10 min
3	**Pre-Task 2** **H56:** Ss watch a sliceshow with pictures and words. Ss write the words that they see next to a definition of the concept. In pairs, ss compare their completion.	R W S	sear – deceptive – poached egg – pan – pot - taste bud – carcinogenic – starch – burst – crave	Matching information	10 min

Objective	Tasks and Procedures	Skill	Language Focus	Strategies	Time
4	**Main Task** **Planning** **M13:** Each st receives a text about the Maillard reaction. Ss are told that they were invited to a food chemistry conference in Dubai in July, 2019 to speak about this reaction. **Rehearsal:** Ss rehearse their speech. T helps out with pronunciation. **Presentation:** In a conference setting, ss present their speech. T takes notes of possible mistakes. **Feedback:** On the board, T writes down possible words that were not correctly pronounced as well as other language problems.	R R S S S		Public speaking	5 min 15 min 10 min 10 min
5	**Post- Task** **H57:** Ss match 5 chemistry-related words with their phonectic transcription. Ss practice the pronunciation of those words.	W S	glycosylamine - ketosamine – pyrolysis – acrylamide - caramelization	Repeating	10 min

Instructions: Watch the video "How to improve your Listening Skills," and write down the four tips that the speaker gives.

Active Listening
Tip 1:_____
Tip 2: _____
Tip 3: _____
Tip 4: _____

Useful language	
What tip is number X?	Tip number X is to…
What do you have in tip number X?	In that tip, I have …

Unit 1 Lesson 1 Handout 2 Oses

Instructions: Complete the following statements using words from the lists.

Bias = predisposition **Frightening = scary** **Coalesce = unite** **Brace = to hold together**

1. Are we removing the bias, or we are creating a construct to pretend the _____ isn't there?

2. One of the most _____ things is the technology that people use to change their color hair.

3. We heat them to 500, 600 degrees, maybe a thousand degrees centigrade, slamming them into each other, so that they _____.

4. Ready for this? _____ yourself! That's how we synthesize semi-conductors in solar energy devices.

Triggering = generating **Randomness = by accident** **Aesthetic = beautiful** **Biomimicry = imitation of biological systems**

5. There are things happening in your brain _____ physiological events.

6. Entropy is the _____ of things, and it's messy, and it's dirty.

7. And if scientists don't have that _____ concept, what do we do?

8. The logic here is to look at _____from a different perspective.

Statements taken from the video Intellectual Ecology, Green Chemistry by John Warner.

Useful Language

What did you write in number X? I wrote…
What word do you have in number X? I have…

Unit 1 Lesson 1 Handout 3	Oses

Instructions: Based on the video "Intellectual Ecology, Green Chemistry," complete the following table by answering the questions.

Intellectual Ecology, Green Chemistry by John Warner	
Main Idea 1	1- What is the role of chemicals in the environment? _____ 2- By asking questions, the speaker raise awareness about the materials that chemists create. What is that awareness? _____
Main Idea 2	3- What concept does science deny to be good science? _____ 4- What is the problem with the teaching of chemistry? _____
Main Idea 3	5- What does the speaker suggest that chemistry should do? _____

Video taken from: https://www.youtube.com/watch?v=TL1zbAJIaDI

Useful Language		
	What is the main idea X?	
The first main idea is…	The second main idea is…	The third main idea is…

Instructions: Read the following excerpt taken from the previous video. Then, write down the main idea. Underline the sentence that was key to identify the main idea.

Here goes another chemistry lesson. So here goes. I'll stay on this side now. So, in thermodynamics, there were two things. There is entropy, and there is enthalpy, okay? Enthalpy is the strength by which things stick together. It's very ordered, okay? And so, we, in science, we take the reductionist approach, and it's very easy to understand enthalpy. Entropy is the randomness of things, and it's messy, and it's dirty, and it's confusing, and so, we oftentimes don't focus on that because we can't master that. We can master the order, the reductionist approach to science, but when it comes to the randomness, we're a little bit fuzzy there. But guess what? Nature works with randomness; nature's designed recipes are all on that side of the equation. Something that we don't feel comfortable with, so we don't do it. We focus on Delta H not because it's better, but it's because what we can understand. And you know what? We need that randomness. We need to embrace that we don't know everything, and accept that because of that lack of full knowledge, we don't know the the downstream impacts of what we're doing, and we should approach it with a bit more humility. But instead of being…but instead of being afraid of that randomness, we've got to look at it, we've got to try to understand it, and we've got to accept that it's beautiful. Right? That there's certain beauty in that, that science, in that randomness, there's a certain amount of beauty. Technology and randomness, there's a certain amount of beauty. And if we can put beauty into invention and science, there'd be a day where all we're doing is celebrating and not worrying. Thank you.

Excerpt taken from the video "Intellectual Ecology, Green Chemistry" by John Warner.

Vocabulary: Strength: Power; force Fuzzy: Unclear Embrace: Adopt; welcome Downstream: Subsequent

The main idea of this paragraph is:

_____

_____

Unit 1 Lesson 1 Answer Key

Handout 1: 1. Focus fully on the speaker. 2. Avoid interrupting. 3. Avoid seeming judgemental. 4. Show your interest.

Handout 2:

1. bias	2. frightening	3. coalesce	4. brace
5. triggering	6. randomness	7. aesthetic	8. biomimicry

Handout 3:

1. Chemicals in the environment are a scary thing. We lack so much knowledge about the impact of chemicals in the environment.

2. The materials hurt the environment. They are hurting us. People make technologies that are problematic.

In short: The materials hurt the environment and people because they are problematic.

3. To be a good science, you must deny the existence of the aesthetic.

4. You will not find one program requiring a student to take a class in toxicology or environmental mechanisms.

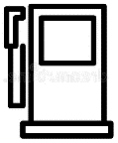
5. The logic here is to look at biomimicry from a different perspective, and bring that into the beakers and flasks people.

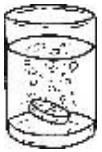
Handout 4: Instead of being afraid of that randomness, we've got to look at it, we've got to try to understand it, and we've got to accept that it's beautiful.

Unit 1 Lesson 2 Handout 5 Oses

Instructions: Read the following **verbs** and their definitions. Then, complete the sentences using them.

VERBS

Pump = to inject 

Fizz = effervesce 

Dissociate = separate 

Tautomerize = the ability of certain organic compounds to react in isomeric structures that differ from each other in the position of a hydrogen atom and a double bond. **Tautomerization is the noun derived from tautomerize.**

Sentences

1. Next time you open a can of soda, the carbonic acid will _____ back to carbon dioxide in water.

2. Soda making companies _____ CO_2 in soda cans.

3. When you open a can of soda, the soda will start to _____.

Sentences taken and adapted from the video "Introduction to enzymes and catalysis."

Useful Language	
What did you write in number X? I wrote…	Number ___ says…
What verb do you have in number X? I have...	In number __, I wrote…

Unit 1 Lesson 2 Handout 6 Oses

Instructions: Go around the class to find the entry of these definitions. Then, complete the sentences using words from the list.

1. _____ = any of several enzymes that catalyze the formation of a long-chain molecule by linking smaller molecular units.

2. _____ ⟶ **Keto** = derived from a ketone +
Enol = an organic compound containing a hydroxyl group attached to a doubly linked carbon atom.

3. _____ = any positively charged atom or group of atoms (opposed to anion).

4. _____ = the process of removing the carboxyl group from an organic compound.

5. _____ = an enzyme that catalyzes the removal of water from a compound.

6. _____= the number of electron pairs that an atom can share with other atoms. **Covalent is the adjective**

Sentences:

1. _____ is when a carboxy or CO_2 group is being taken off a molecule.

2. _____bonds involves two molecules sharing electrons.

3. The saliva has an enzyme called carbonic _____.

4. DNA _____ is the enzyme that allows DNA replication to occur.

Useful Language
What do you have in number X?.
In number X, I wrote…

Sentences taken and adapted from the video "Introduction to enzymes and catalysis."

Word Families: Some words can create families

Verb	Noun	Adjective
provide	provision	providing

1. Instructions: Complete the chart by creating word families.

Verb	Noun	Adjective
Collide	_____	_____
_____	_____	dividing

Useful Language
The verb is…
The noun is…
The adjective is…

2. Instructions: Complete this passage using collide word family.

The orientation of the two 1. _____ molecules in space is also really important. If molecule A and molecule B 2. _____, but one of them is upside down or not in the correct position, then the 3. _____ may not result in a successful reaction.

Sentences taken and adapted from the video "Introduction to enzymes and catalysis."

Useful Language

What did you write in number X?	In number __, I wrote…
What do you have in number X?	In that one, I have…

Unit 1 Lesson 2 Handout 8 Oses

Instructions: Watch the video "Introduction to enzymes and catalysis". Then write down the main ideas.

Main idea 1:_____

Main idea 2:_____

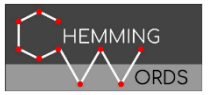
Main idea 3:_____

Main idea 4:_____

Main idea 5:_____

Useful Language	
What is the main idea number X?	I think that main idea X is …
What do you have in number X?	I have…

Unit 1 Lesson 2 Handout 9 Oses



Instructions: Watch the video "Introduction to enzymes and catalysis". Then, answer the questions.

Main idea 1: Enzymes

1. What is the importance of the enzymes? _____

2. What example does the speaker give to illustrate the reaction with enzymes?_____

3. What is the pop sound that you hear when you open a can of soda?_____

4. What happens after you open a can of soda?_____

5. When a person drinks soda, why will the soda start fizzing a lot more?_____

Main idea 2: Acid/base catalysis

1. How do enzymes act like? _____

2. What do acids and bases donate and accept?_____

3. What kind of reaction does acid/base catalysis produce?_____

Main idea 3: Covalent catalysis

1 When does covalent catalysis happen? _____

2 What kind of reaction does covalent catalysis produce?_____

3 What do electrons do in decarboxylation reactions?_____

Main idea 4: Electrostatic catalysis

1. What does an enzyme need to have to stabilize the negative charge found in DNA?_____

2. What element has metal cations?_____

3. What enzyme allows DNA replication to occur?_____

Main idea 5: Proximity and orientation effects

1. What do molecules need to react which each other? _____

2. What is important to remember about two colliding molecules in space?_____

3. What happens if two molecules collide but one is upside down or not in the correct position?_____

_____

Unit 1 Lesson 2 Handout 10 Oses

Adjective + ly = Adverb ► Natural + ly = naturally **Example: Enzymes are produced naturally.**

1. Instructions: Transform the following adjectives into adverbs. Then, complete the sentences using the adverbs.

1. quick ⟶ _____ 2. real ⟶_____ 3. negative ⟶ _____

1. We learned that the role enzymes play is to make biochemical reactions happen more _____.

2. The orientation of the two colliding molecules in space is also_____ important.

3. DNA is a very_____ charged polymer.

2. Instructions: Listen to the video and fill in the blanks with the words that the speaker says. The words are all adverbs.

Our next catalytic strategy is covalent catalysis which happens when enzymes form a covalent bond with another molecule, (1) _____ their target molecule. Remember that covalent bonds involves two molecules sharing electrons. And looking at this reaction here, we have a decarboxylation reaction going on. Which, if you remember from organic chemistry, is when a carboxy or CO_2 group is being taken off a molecule. And if you remember, these reactions (2) _____have a lot of electrons moving around. So if we had a (3) _____ bound enzyme that could hold on to some electrons, be an electron carrier, or what some people like to call an electron sink, then that would (4)_____ help this type of reaction move a little more (5)_____.

Useful Language
In number X, the adverb is …

Unit 1 Lesson 2 Answer Key

Handout 5: 1. dissociate 2. pump 3. fizz

Handout 6: 1. decarboxylation 2. Covalent 3. anhydrase 4. Polymerase

Polymerase = any of several enzymes that catalyze the formation of a long-chain molecule by linking smaller molecular units.
Keto-enol = Keto = derived from a ketone + **Enol** = an organic compound containing a hydroxyl group attached to a doubly linked carbon atom.
Cation = any positively charged atom or group of atoms (opposed to anion).
Decarboxylation = the process of removing the carboxyl group from an organic compound.
Anhydrase = an enzyme that catalyzes the removal of water from a compound.
Covalence = the number of electron pairs that an atom can share with other atoms.

Handout 7:

1. Verb	**Noun**	**Adjective**
Collide	Collision	Colliding
Divide	Division	Dividing

2. 1. colliding 2. collide 3. collision

Handout 8:
Main idea 1: Enzymes
Main idea 2: Acid/base catalysis
Main idea 3: Covalent catalysis
Main idea 4: Electrostatic catalysis.
Main idea 5: Proximity and orientation effects

Handout 9:

Main idea 1: Enzymes:

1. Enzymes make reactions go much faster.
2. Soda or any carbonated beverage
3. It is a bunch of CO2 escaping.
4. The carbonic acid dissociates back to carbon dioxide in water.
5. Humans have an enzyme in their blood and saliva called carbonic anhydrase.

Main idea 2: Acid/base catalysis

1. Enzymes act like acids or bases.
2. Protons.
3. A keto-enol tautomerization reaction.

Main idea 3: Covalent catalysis

1. When enzymes form a covalent bond with another molecule.
2. A decarboxylation reaction
3. Electrons move around.

Main idea 4: Electrostatic catalysis

1. metal cation
2. Magnesium
3. DNA polymerase

Main idea 5: Proximity and orientation effects

1. They need to physically collide.
2. Orientation
3. The collision may not result in a successful reaction.

Handout 10:

Part 1. 1. quickly 2. really 3. negatively

1. We learned that the role enzymes play is to make biochemical reactions happen more **quickly**.
2. The orientation of the two colliding molecules in space is also **really** important.
3. DNA is a very **negatively** charged polymer.

Part2:

1- usually 2- usually 3- covalently 4- definitely 5- quickly

Instructions: Read the following definitions. Then, match the pictures with a concept.

VERB

1. Swap: to exchange or trade, as one thing for another.

NOUNS

2. Shell: A set of electron orbitals with the same principal quantum number.

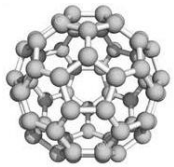
3. Allotrope: different structures of the same element.

4. Fullerene: a carbon molecule shaped like a rugby ball closely related to the buckminsterfullerene. (the form of fullerene having sixty carbon atoms).

5. Halide: a chemical compound in which one of the elements is a halogen.

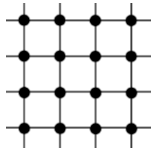
6. Lattice: The regular arrangement of atoms, ions, or molecules in a crystalline solid.

(___)



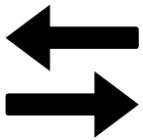
Picture 1

(___)



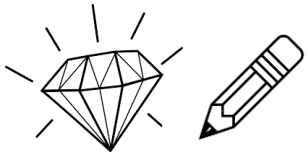
Picture 2

(___)



Picture 3

(___)



Picture 4

Useful Language

What picture illustrates word X? Picture X illustrates word …

What number did you write in picture X? I wrote …

Instructions: Complete the following sentences using words from the previous list.

1. Graphite and diamond are _____ of carbon.

2. A fluoride ion and a chloride ion are examples of _____.

3. A _____ is an allotrope of carbon in the form of a hollow sphere, ellipsoid, tube, and many other shapes.

4. When very different atoms react like metals and nonmetals, they normally _____ electrons; this is ionic bonding.

5. Only the noble gases exist naturally as single atoms. All the other elements of the periodic table have partially filled valence _____.

Sentences taken from:
1. https://www.dictionary.com/browse/allotrope?s=t
2. https://socratic.org/questions/what-are-examples-of-halides
3. https://en.wikipedia.org/wiki/Fullerene
4.-5. https://www.youtube.com/watch?v=h24UmH38_LI&t=89s

Useful Language

What word do you have in number X? I have…
What did you write in number X? I wrote…
In sentence X, the word is…

Unit 1 Lesson 3 Handout 13 Oses

Instructions: Fill in the blanks with the words that you listen from the video "What Are Covalent Bonds?"

Atoms bond by swapping or sharing electrons in their outer shells. (1)_____very different atoms react like metals and nonmetals, they normally swap electrons; this is ionic bonding. (2)_____ similar atoms react, like nonmetals combining with other nonmetals, they share electrons. This is covalent bonding. Nonmetals are found on the right hand side and upper part of the periodic table. Some common nonmetals are carbon, nitrogen, oxygen, and the halides. They have shells of electrons that are normally half or more than half full of electrons. (3)_____ they have a strong attraction for a few additional electrons, it is energetically unfavorable for them to lose electrons, (4)_____ they share electrons by overlapping orbitals.

Excerpt taken from the video "What Are Covalent Bonds?"

Useful Language
What word do you have in number X? I have…
What did you write in number X? I wrote…

Instructions: Fill in the blanks with the words that you listen from the video "What Are Covalent Bonds?"

(1) _____ the electrons in the bonds are evenly shared, bonds are not polarized. There is little attraction between molecules, (2) _____forces between molecules are weak. Compounds made from small covalent molecules have low melting and boiling points, (3) _____ are volatile. They (4) _____ don't conduct electricity. Carbon and silicon tend to form giant covalent compounds. These bond in the same way, (5)_____instead of forming small molecules with one or two bonds, they form four, making up huge lattices or chains of many many linked up atoms.

Excerpt taken from the video "What Are Covalent Bonds?"

Useful Language

What word do you have in number X? I have…
What did you write in number X? I wrote…

Instructions: Fill in the blanks with the words that you listen from the video "What Are Covalent Bonds?"

One common example is diamond, which is made of carbon. Each carbon atom forms four covalent bonds (1)_____ it has four electrons in its outer shell to share, (2) _____ has space for four more. If every carbon atom forms four bonds with four other carbon atoms, (3) _____each of these forms four bonds with four other carbon atoms, (4) _____ each of these forms four bonds. We very quickly end up with a very large structure. These compounds have very high melting and boiling points 5. _____ you have to break covalent bonds rather than intermolecular forces to make them free enough to act as liquids or gases.

Excerpt taken from the video "What Are Covalent Bonds?"

Useful Language
What word do you have in number X? I have…
What did you write in number X? I wrote…

Unit 1 Lesson 3 Handout 16 Oses

Instructions: Complete these sentences using **<u>two different connectors</u>** to give a reason, add information, show contrast, and show consequence.

<u>To Give a Reason or Cause</u>

1. _____ the electrons in the bonds are evenly shared, bonds are not polarized.

2. _____ the electrons in the bonds are evenly shared, bonds are not polarized.

<u>To Add Information</u>

1. There is little attraction between molecules; _____, forces between molecules are weak.

2. There is little attraction between molecules; _____, forces between molecules are weak.

Useful Language
-What are connectors to …?
-You can use … or …

To Show Contrast

1. Silicon dioxide is a giant covalent structure, and just like diamond. _____, it has oxygen atoms bridging between four coordinates silicon atoms.

2. Silicon dioxide is a giant covalent structure, and just like diamond. _____, it has oxygen atoms bridging between four coordinates silicon atoms.

To Show Consequence

1. It is energetically unfavorable for common nonmetals to lose electrons._____, they share electrons by overlapping orbitals.

2. It is energetically unfavorable for common nonmetals to lose electrons._____, they share electrons by overlapping orbitals.

Sentences taken and adapted from the video "What Are Covalent Bonds?"

Useful Language
-What are connectors to …?
-You can use … or …

Instructions: Complete these passages using connectors from the posts.

Passage 1.

(1)_____the electrons in the bonds are evenly shared, bonds are not polarized. There is little attraction between molecules. (2) _____, forces between molecules are weak. Compounds made from small covalent molecules have low melting and boiling points. (3)_____, these compounds are volatile. They also don't conduct electricity. Carbon and silicon tend to form giant covalent compounds. These bond in the same way; (4)_____, instead of forming small molecules with one or two bonds, they form four, making up huge lattices or chains of many many linked up atoms.

Passage 2.

One common example is diamond, which is made of carbon. Each carbon atom forms four covalent bonds (1)_____ it has four electrons in its outer shell to share, and has space for four more. If every carbon atom forms four bonds with four other carbon atoms, and each of these forms four bonds with four other carbon atoms. (2) _____, each of these forms four bonds. We very quickly end up with a very large structure. These compounds have very high melting and boiling points (3) _____ you have to break covalent bonds rather than intermolecular forces to make them free enough to act as liquids or gases.

Passages taken from the video "What Are Covalent Bonds?"

Useful Language
In passage X, I wrote…

Unit 1 Lesson 3 Answer Key

Handout 11: (4) (6) (1) (3)

Handout 12: 1. Allotropes 2. halides 3. fullerene 4. swap 5. Shells

Handout 13: 1. When 2. But 3. Since 4. so

Handout 14: 1. Because 2. and 3. and 4. also 5. But

Handout 15: 1. because 2. and 3. and 4. and 5. Because

Handout 16:

Connectors to give a reason or cause
Because = As / Since / Seeing that

Connectors to add information
And = Moreover / Furthermore / In addition

Connectors to show contrast
But = However / Nevertheless / On the contrary

Connectors to show consequence
So = Consequently / As a consequence / As a result / Therefore

Handout 17:

Passage 1.
1. As / Since / Seeing that 2.- 3. Moreover / Furthermore / In addition
4. However / Nevertheless / On the contrary

Passage 2.
1. As / Since / Seeing that 2. Moreover / Furthermore / In addition 3. As / Since / Seeing that

Vocabulary and Expressions

Acidic: Acids are proton donors. Substances with a pH less than 7 are considered to be acidic.

Made up of: formed by

Shell: a hard outer covering of an animal, as the hard case of a mollusk.

A double whammy: a combination of two usually adverse forces, circumstances, or effects.

Silver lining: a sign of hope in an unfortunate situation.

Sentences

1. Studies are showing that if we decrease the pH, and make it more

_____, organisms are having a decrease in metabolism,

2. A_____ is made up of calcium carbonate.

3. This contamination problem is harmful; however, there is a _____.

4. The bulk of a coral reef is _____ calcium carbonate.

Useful Language	
What do you have in sentence X?	I have …
What did you write in sentence X?	In that sentence, I wrote…
What is the word in sentence X?	I think the word is …

UNIT 1 ASSESSMENT TASK

Total points: 20 Obtained Points: ____ Score: _____ Percentage: 25 % / ____

Student's name: _____ **Date:** September 12, 2018.

Instructions: You were invited to a conference as a presenter. Listen to the audio to get the following information to speak about.

General Information

1. Topic: _____ 2pts / ____

2. The main idea of the speaker is that _____

_____. 2pts / ____

Specific Details

3. What example does the speaker use to illustrate his point? _____ 2pts / ____

4. Fill in the blanks with the ocean pH levels in each period of time. 3 pts. / ____

4.1 Pre-industrial levels _____ 4.2 Post industrialization _____ 4.3 In the future _____

5. What determines the concentration of carbonic acid, bicarbonate, and carbonate? 1pt / ____

_____

6. What happens if we decrease the levels of pH? 2pts / ____

_____

7. What happens if we put a shell at 7.8 pH? 2pts / ____

_____

8. What is the double whammy that coral reef is hit with? 2pts / ____

_____

9. What is the silver lining of both global warning and ocean acidification? 2pts / ____

_____

10. What is the solution? 2pts / ____

_____

Unit 1 Assessment Lesson Handout 21 Oses

Instructions: With the information that you collected, create chart with five pieces of information to talk about at the conference you were invited.

Topic:_____

1._____

_____

2._____

_____

3._____

_____

4._____

_____

5._____

_____

Useful Language

Good evening. I am going to speak about…

To start my presentation, I have to tell you that…

I can also tell you that…

Moreover, …

In addition,…

Finally, the solution is to…

Thanks for your attention, and have a good night.

Unit 1 Assessment Lesson Answer Key

Handout 18

1. Coral are **animals.**
2. Corals are **mega builders.**
3. Coral reefs are some of the most diverse **ecosystem on earth.**
4. Coral are **translucent.**
5. Coral provide **a window to the past.**

1.1 As big as a basketball.

2.1 Australia

3.1 25 %

4.1 b. from algae

5.1 layers or rings

Handout 19 1. acidic 2. Shell 3. silver lining 4. made up of

Handout 20 -21

1. Ocean Acidification
2. Life is regulated by proteins, and proteins require a specific pH.
3. distilled water with carbon dioxide or carbonated water
4. Pre-industrial levels = 8.25 Post industrialization = 8.14 In the future = 7.80
5. The temperature of the ocean water.
6. The carbonate levels are going to drop off and the bicarbonate levels are going to increase.
7. It is literally going to dissolve.
8. Global warming and ocean acidification.
9. They have the same cause.
10. The solution is to decrease the amount of carbon dioxide.

Unit 2 Lesson 1 Handout 22 Oses

Instructions: Complete the following graphic organizer with information from the video "Matter Chatter."

State of matter	Characteristics	Examples
1. _____	1.1 stay put in a single place. 1.2 _____	_____ _____
2. _____	2.1 _____ 2.2 _____	_____ _____
3. _____	3.1 _____ 3.2 _____	_____ _____

Useful Language	
What state of matter do you have in number X?	I have…
What characteristics did you write in number X?	I wrote…
What are examples of …?	Some examples are…

Unit 2 Lesson 1 Handout 23 Oses

Instructions: Use the following phrases to complete the sentences below.

the amount of space taken up by something.
it takes up space, and has weight.
just how heavy something is.
anything that has weight and takes up space.

Vocabulary

Weight (noun): the amount or quantity of heaviness or mass
Weigh (verb)
Take up (verb): to occupy or cover

1. Matter is _____

2. Weight is _____

3. Volume is _____

4. Air is matter because _____

Useful Language	
What did you write in sentence X?	I wrote…..
How did you complete sentence X?	I have…
I think the correct sentence is…	I think sentence X is…

Instructions: Read the text. Then, write questions using the clues given.

1. Matter Definition and Examples

There are many possible definitions for matter. In science, matter is the term for any type of material. Matter is anything that has mass and takes up space. At a minimum, matter requires at least one subatomic particle, although most matter consists of atoms. The word "matter" is sometimes used to refer to a pure substance.

Examples of Matter

Proton	Atoms (e.g., a helium atom)	Molecules (e.g., water, sugar)	Compounds (e.g., table salt, silicon dioxide)
Cat	Tree	House	Computer

Examples That Are Not Matter

Not everything we can perceive consists of matter. Examples of things that aren't matter include:

Photons (light) Heat Thoughts Microwaves

Taken from: https://www.thoughtco.com/definition-of-matter-and-examples-604565

1. You want to know

1.1 a definition of matter: _____

1.2 matter requirement:_____

1.3 what most matter consists of: _____

1.4 examples of matter: _____

1.5 things that are no matter:_____

Instructions: Read the text. Then, write questions using the clues given.

2. Physical Properties

Physical properties are any properties of matter which can be perceived or observed without changing the chemical identity of the sample. In contrast, chemical properties are those that can only be observed and measured by performing a chemical reaction, thus changing the molecular structure of the sample.

Because physical properties include such a wide array of characteristics, they are further classified as either intensive or extensive and either isotropic or anisotropic.

Taken from https://www.thoughtco.com/physical-properties-of-matter-608343

2. You want to know

2.1 the properties of matter:_____

2.2 the classification of physical properties: _____

2.3 the reason why matter is classified as either intensive or extensive and either isotropic or anisotropic:

_____

Instructions: Read the text. Then, write questions using the clues given.

3. Intensive and Extensive Physical Properties: Physical properties may be classified as either intensive or extensive. Intensive physical properties do not depend on the sample's size or mass. Examples of intensive properties include boiling point, state of matter, and density. Extensive physical properties depend on the amount of matter in the sample. Examples of extensive properties include size, mass, and volume.
Extensive Property Definition: An extensive property is a property of matter that changes as the amount of matter changes. Like other physical properties, an extensive property may be observed and measured without any chemical change (reaction) occurring.
Extensive Property Examples: Mass and volume are extensive properties. As more matter is added to a system, both mass and volume changes.
Extensive Versus Intensive Properties: In contrast to extensive properties, intensive properties do not depend on the amount of matter in a sample. They are the same whether you're looking at a large amount of material or tiny quantity. An example of an intensive property is electrical conductivity. The electrical conductivity of a wire depends on its composition, not the length of the wire. Density and solubility are two other examples of intensive properties.

Taken from https://www.thoughtco.com/physical-properties-of-matter-608343

3. You want to know

3.1 the definition of extensive property:_____

3.2 examples of extensive properties:_____

3.3 what extensive physical properties depend on: _____

3.4 examples of intensive properties:_____

3.5 the difference between extensive and intensive properties: _____

Instructions: Read the text. Then, write questions using the clues given.

4. Isotropic and Anisotropic Properties

Physical properties are isotropic properties if they do not depend on the orientation of the specimen or direction from which it is observed. The properties are anisotropic properties if they do depend on the orientation. While any physical property could be assigned as isotropic or anisotropic, the terms are usually applied to help identify or distinguish materials based on their optical and mechanical properties. For example, one crystal might be isotropic with respect to color and opacity, while another might appear a different color, depending on the viewing axis. In a metal, grains might be distorted or elongated along one axis compared with another.

Taken from https://www.thoughtco.com/physical-properties-of-matter-608343

4. You want to know

4.1 the moment when physical properties are isotropic_____

4.2 the moment when physical properties are anisotropic_____

4.3 the reason why the terms are usually applied:_____

4.4 an example to show the difference between the terms: _____

_____

Instructions: Read the text. Then, write questions using the clues given.

5. Physical Properties of Ionic vrs. Covalent Compounds

The nature of chemical bonds plays a role in some of the physical properties that may be displayed by a material. The ions in ionic compounds are strongly attracted to other ions with opposite charge and repelled by like charges. Atoms in covalent molecules are stable and not strongly attracted or repelled by other parts of the material. As a consequence ionic solids tend to have higher melting points and boiling points, compared with low melting and boiling points of covalent solids. Ionic compounds tend to be electrical conductors when they are melted or dissolved, while covalent compounds tend to be poor conductors in any form. Ionic compounds are usually crystalline solids, while covalent molecules may exist as liquids, gases, or solids. Ionic compounds often dissolve in water and other polar solvents, while covalent compounds are more likely to dissolve in nonpolar solvents.

Taken from https://www.thoughtco.com/physical-properties-of-matter-608343

5. You want to know

5.1 the condition of the ions in ionic compounds:_____

5.2 the condition of atoms in covalent molecules:_____

5.3 the difference between ionic and covalent compounds regarding electrical conductivity: _____

_____

5.4 where ionic compounds dissolve:_____

5.5 where covalent compounds dissolve:_____

Instructions: Read the text. Then, write questions using the clues given.

6. Physical Properties vs Chemical Properties

Chemical properties encompass those characteristics of matter which can only be observed by changing the chemical identity of a sample, which is to say, by examining its behavior in a chemical reaction. Examples of chemical properties include flammability (observed from combustion), reactivity (measured by readiness to participate in a reaction), and toxicity (demonstrated by exposing an organism to a chemical).

Taken from https://www.thoughtco.com/physical-properties-of-matter-608343

6. You want to know

6.1 characteristics that chemical properties encompass:_____

6.2 examples of chemical properties:_____

Instructions: Read the text. Then, write questions using the clues given.

7. Chemical and Physical Changes

Chemical and physical properties are related to chemical and physical changes. A physical change only alters the shape or appearance of a sample and not its chemical identity. A chemical change is a chemical reaction, which rearranges a sample on a molecular level.

Taken from https://www.thoughtco.com/physical-properties-of-matter-608343

7. You want to know

7.1 what chemical and physical properties are related to:_____

7.2 what a physical change alters:_____

7.3 on what level a chemical reaction rearranges a sample:_____

Unit 2 Lesson 1 Handout 25 Oses

In Simple Present Tense

What is **carbon**? Use **is** when the subject is singular, and there is **no** verb.
What are **electrons**? Use **are** when the subject is plural, and there is **no** verb.

How does carbon **react**? Use **does** when the subject is singular, and **there is a verb**.
How do electrons **bind**? Use **do** when the subject is plural, and **there is a verb**.

Instructions: Complete these sentences with **is**, **are**, **do,** or **does**.

is/are

1. What _____ matter?
2. What _____ examples of matter?
3. What _____ physical properties of matter?
4. What _____ the definition of extensive property?
5. What _____ an example of extensive properties?
6. How _____ the ions in ionic compounds?

do/does

1. What _____ matter require?
2. Where _____ an ionic compound dissolve?
3. What characteristics _____ chemical properties encompass?
4. Where _____ covalent compounds dissolve?
5. What _____ a physical change alter?
6. What _____ extensive physical properties depend on?

Useful Language

What did you write in question X?	I wrote…
What do you have in number X?	I have…

Unit 2 Lesson 1 Answer Key

Handout 22

State of matter	Characteristics	Examples
1. Solids	1.1 stay put in a single place. 1.2 keep their own shape.	A chair, a box, a shirt, socks, a table, a phone, a cookie, a stone
2. Liquids	2.1 Flow when they move around. 2.2 Take the shape of the container	water, apple juice, milk, soda, gasoline, salad dressing,
3. Gas	3.1 Expands to fill any space. 3.2 Are sometimes invisible.	Air, helium, wind, smoke, steam, air conditioning

Handout 23

1. Matter is anything that has weight and takes up space.
2. Weight is just how heavy something is.
3. Volume is the amount of space taken up by something.
4. Air is matter because it takes up space and have weight.

Handout 24

1.1 What is matter?
1.2 What does matter require?
1.3 What does matter consist of?
1.4 What are examples of matter?
1.5 What things are not matter?

2.1 What are physical properties of matter?
2.2 How are physical properties classified?
2.3 Why matter is classified as either intensive or extensive and either isotropic or anisotropic?

3.1 What is the definition of extensive property?
3.2 What are examples of extensive properties?
3.3 What do extensive physical properties depend on?
3.4 What are examples of intensive properties?
3.5 What is the difference between extensive and intensive properties?

4.1 When are physical properties isotropic?
4.2 When are physical properties anisotropic?
4.3 Why are the terms usually applied?
4.4 What is an example to show the difference between the terms?

5.1 How are the ions in ionic compounds?
5.2 How are atoms in covalent molecules?
5.3 What is the difference between ionic and covalent compounds regarding electrical conductivity?
5.4 Where do ionic compounds dissolve?
5.5 Where do covalent compounds dissolve?

6.1 What characteristics do chemical properties encompass?
6.2 What are some examples of chemical properties?

7.1 What are chemical and physical properties related to?
7.2 What does a physical change alter?
7.3 What level does a chemical reaction rearrange a sample on?

Handout 25

is/are	**do/does**
1. What is matter?	1. What does matter require?
2. What are examples of matter?	2. Where does an ionic compound dissolve?
3. What are physical properties of matter?	3. What characteristics do chemical properties encompass?
4. What is the definition of extensive property?	4. Where do covalent compounds dissolve?
5. What is an example of extensive properties?	5. What does a physical change alter?
6. How are the ions in ionic compounds?	6. What do extensive physical properties depend on?

Unit 2 Lesson 2 Handout 26 Oses

Instructions: Complete this chart using phrases to introduce indirect questions from the video "Indirect Questions."

How to Be Polite

1._____

Replies: 1.1 You are welcome 1.2_____ 1.3 _____

2. _____

Greetings: 2.1 Hi there. 2.2 _____ 2.3 _____

3. _____ **It is better to say:** 3.1_____

4. _____

5. _____

Useful Language

Could you tell me what you wrote in number X, please?	Sure! I wrote…
I would like to know what you have in number X.	I have…

Unit 2 Lesson 2 Handout 27 Oses

Instructions: Complete this chart using phrases to introduce indirect questions from the video "Indirect Questions."

Indirect Questions
What are indirect questions?_____
Phrases to introduce Indirect Questions
1._____
2. _____
3. _____
4. _____

Useful Language	
I would like to know what answer you wrote.	I wrote…
Could you tell me what you have in number X, please?	I have…
I would like to know what you wrote in number X, please.	Sure, I wrote

Unit 2 Lesson 2 Handout 28 Oses

Instructions: Complete the chart with the ten strangest elements from the video "10 Strangest Elements."

10. _____	9. _____	8. _____	7. _____
6. _____	5. _____	4. _____	
3. _____	2. _____	1. _____	

Instructions: Read the following text and write indirect questions.

Lutetium is a silvery white metal that was first discovered in 1907 by three scientists, who had each discovered the element independently of each other. Lutetium cannot be found in its purest state, as it is always found bound up with some other elements. But lutetium is a very unusual element because of its extreme rarity, yet not existent practical applications.
In fact, lutetium is so rare, that it is not only the rarest of all rare earth elements, but the entire global production of lutetium is just 10 tons each year. But beyond that, this strange substance has very few practical uses. In fact, just about the only thing that lutetium is even useful for, is determining the age of meteorites. And because of how rare it is, and how difficult it is to mine, lutetium is one of the most expensive rare earth metals, costing approximately 10,000 USD per kilogram.

You need to know

1. what color lutetium is._____

2. when lutetium was discovered._____

3. why lutetium is so rare._____

4. what the entire global production of lutetium is._____

5. what the price of a kilogram of lutetium is._____

Unit 2 Lesson 2 Handout 28 Oses

Instructions: Complete the chart with the ten strangest elements from the video "10 Strangest Elements."

10. _____	9. _____	8. _____	7. _____
6. _____	5. _____	4. _____	
3. _____	2. _____	1. _____	

Instructions: Read the following text and write indirect questions.

Technetium was given its name after the Greek word for artificial because the only method of obtaining this element is through artificial means. But technetium is not entirely an artificial element. In fact, through spectrographic analysis, technetium has been detected in the cores of many stars. Beyond that, though, technetium can only be created through nuclear fission. Large quantities of technetium are typically produced using spent nuclear fuel rods, but on top of how difficult technetium is to forge, technetium is only present for just a few seconds during nuclear reactions. This is because technetium has no stable isotopes and quickly decays out of existence. In fact, most isotopes of technetium have half-lives of just under an hour. Beyond that, technetium, for the most part, is a strange, yet short lived, nuclear byproduct.

You need to know

1. what the meaning of technetium is._____

2. how technetium is obtained._____

3. where technetium has been located._____

4. how technetium can be created._____

5. how long technetium is present during nuclear reactions._____

Unit 2 Lesson 2 Handout 28 Oses

Instructions: Complete the chart with the ten strangest elements from the video "10 Strangest Elements."

10. _____	9. _____	8. _____	7. _____
6. _____	5. _____	4. _____	
3. _____	2. _____	1. _____	

Instructions: Read the following text and write indirect questions.

Without silicon, our lives would be much, much different because silicon is the key ingredient behind computer chips and many other crucial electronics. Without it, our electronics in our lives, as we know it, would radically change for the worse. Fortunately, we don't need to worry about running out of this element any time soon because silicon is a naturally occurring element that comprises roughly 27% of the earth's crust. Because of the immense importance of silicon, the section of San Francisco that is home to the biggest technology firms in the world, is aptly named after this element. The place is called Silicon Valley.

You need to know

1. how our lives would be without silicon._____

2. what the key ingredient behind computer chips is._____

3. what the percentage that silicon comprises is._____

4. where the biggest technology firms in the world are._____

5. what the name of the place is._____

Unit 2 Lesson 2 Handout 28 Oses

Instructions: Complete the chart with the ten strangest elements from the video "10 Strangest Elements."

10. _____	9. _____	8. _____	7. _____
6. _____	5. _____	4. _____	
3. _____	2. _____	1. _____	

Instructions: Read the following text and write indirect questions.

Gallium is a metal with a very unique property. Its melting point is 29.77 Celsius, which means that gallium will invariably transition into its liquid state right in your hand. Many people usually are shocked to see an otherwise dense metal turned to ooze with just a touch of a hand, and there is little to fear from gallium. Unlike mercury, gallium is a nontoxic element and is quite safe to be handled. Once it is removed from your hands, gallium will return to its metallic state. A popular prank among scientists in the 1920s was to mold gallium to the shape of silverware and then leave it for their coworkers to use while eating lunch. The pranksters would then watch as their colleagues screamed in horror as their utensils melted right out of their hands while they were eating.

You need to know

1. what the melting point of gallium is._____

2. where gallium will transition into its liquid state._____

3. how toxic gallium is._____

4. what happens when you remove gallium form your hands._____

5. what a popular prank among scientists in the 1920s was._____

Unit 2 Lesson 2 Handout 28 Oses

Instructions: Complete the chart with the ten strangest elements from the video "10 Strangest Elements."

10. _____ 9. _____ 8. _____ 7. _____

6. _____ 5. _____ 4. _____

3. _____ 2. _____ 1. _____

Instructions: Read the following text and write indirect questions.

The symbol for francium is Fr, which mirrors the ISO code for the country of France. This is unsurprising because this element is actually named after France. Francium is one of the alkaline metals and is best known for being the heaviest of the metals on the periodic table and also the most unstable. Little is known about Francium because it is so incredibly rare. It is theorized that on earth, francium only pops into existence one atom at a time and is stable for, at most, 22 minutes. This is because when Francium comes into contact with water, it will violently explode and leave the surrounding area flooded with radiation. This element is particularly dangerous because the moisture in the air alone is enough to trigger an explosive reaction. Scientists have estimated that only about 20 grams of Francium can be found in the entire planet, at any one time. As of this video's release, no practical uses for Francium have been discovered, and no one has managed to collect enough Francium to study this strange element in depth.

You need to know

1. what the symbol for francium is._____

2. what country is francium named after._____

3. how long francium is stable._____

4. why francium is dangerous._____

5. how many grams of francium are found in the planet._____

Unit 2 Lesson 2 Handout 28 Oses

Instructions: Complete the chart with the ten strangest elements from the video "10 Strangest Elements."

10. _____	9. _____	8. _____	7. _____
6. _____	5. _____	4. _____	
3. _____	2. _____	1. _____	

Instructions: Read the following text and write indirect questions.

Curium. This element is a man-made element that was first discovered by Glenn Seaborg, and was named in honor of the esteemed chemist Marie Curie. What makes this element so bizarre is that it is dangerously radioactive. In fact, curium is so radioactive that it will actually glow in the dark. Curium has been used as a power supply for NASA deep space probes because it is stable enough to generate power for decades on and thanks to its strong radioactive properties. Many have attempted to use curium in pacemakers because it can serve as a stable power source. This is particularly useful because a curium powered pacemaker could theoretically operate without interruption for decades at a time, reducing the need for followup surgeries. However, unfortunately for that endeavor, curium glows bright enough to be seen straight through a human chest, and to this day, this element is rarely used due to its unusually strong radioactive admissions.

You need to know

1. who curium was named in honor to._____

2. why this element is so bizarre._____

3. why NASA has been using curium._____

4. why many have attempted to use curium in pacemakers._____

5. what the problem is with using curium in pacemakers._____

Unit 2 Lesson 2 Handout 28 Oses

Instructions: Complete the chart with the ten strangest elements from the video "10 Strangest Elements."

10. _____	9. _____	8. _____	7. _____
6. _____	5. _____	4. _____	
3. _____	2. _____	1. _____	

Instructions: Read the following text and write indirect questions.

Antimony. This unusual element has had a long history with humans, dating all the way back to 3,000 BC. Antimony was commonly used to make small items and was even used in ancient Egypt as a form of eyeliner. Centuries later, antimony was used by monks to study alchemy. Unfortunately, all of these groups failed to understand the true nature of antimony. Antimony received its modern name from the French word for monk killer. This is because antimony is unusually toxic to humans, but as previously mentioned, its practical applications drove many civilizations throughout history to use this clearly dangerous element. Today, antimony is primarily used as a flame retardant, and unfortunately, the world supply of antimony is quickly depleting.

You need to know

1. how antimony was used in ancient Egypt._____

2. how antimony was used by monks._____

3. how toxic antimony is._____

4. what application antimony has today._____

5. what the problem is with antimony._____

Unit 2 Lesson 2 Handout 29 Oses

When you ask an indirect question, the word order changes from **VERB + SUBJECT** to **SUBJECT + VERB**
Example: What color **is** **lutetium**? Could you tell me what color **lutetium** **is**?

The structure of an indirect question is: **Could you tell me** (Introductory Phrase) + **what** (wh word) + **the symbol for francium** (subject) + **is?** (Verb)

Instructions: Transform the following direct questions into indirect ones.

1. When was lutetium discovered? _____

2. Why is lutetium so rare? _____

3. Where has technetium been located?_____

4. How can technetium be created?_____

5. What is the key ingredient behind computer chips?_____

6. Where are the biggest technology firms in the world?_____

7. Where will gallium transition into its liquid state? _____

8. How toxic is gallium?_____

Useful Language

I would like to know what you wrote in number X. I wrote…
Could you tell me how you transformed question X? Sure! I wrote…

Unit 2 Lesson 2 Answer Key

Handout 26

1. Remember your "Ps and Qs" (Please and Thank you). 1.2. Not at all 1.2 It's a pleasure

2. Start with a greeting. 2.2 Hi 2.3 Good morning.

3. Avoid saying "I want" 3.1 I'd like

4. Say sorry

5. Say "Excuse me!"

Handout 27

Indirect Questions: They are more formal and polite questions.

Phrases to introduce Indirect Questions:

1. Could you tell me 2. Do you know 3. Do you have any idea 4. I would like to know

Handout 28

10. lutetium 9. Technetium 8. Silicon 7. gallium 6. francium 5. curium 4. antimony 3. Bismuth
2. elements 112 through 118 1. Carbon

Lutetium

1. Could you tell me what color lutetium is?
2. … when lutetium was discovered?
3. … why lutetium is so rare?
4. … what the entire global production of lutetium is?
5. … what the price of a kilogram of lutetium is?

Technetium

1. Do you know what the meaning of technetium is?
2. … how technetium is obtained?
3. … where technetium has been located?
4. … how technetium can be created?
5. … how long technetium is present during nuclear reactions?

Silicon
1. Do you have any idea how our lives would be without silicon?
2. … what the key ingredient behind computer chips is?
3. … what the percentage that silicon comprises is?
4. … where the biggest technology firms in the world are?
5. … what the name of the place is?

Francium
1. Could you tell me what the symbol for francium is?
2. … what country is francium named after?
3. … how long francium is stable?
4. … why francium is dangerous?
5. … how many grams of francium are found in the planet?

Antimony
1. Do you have any idea how antimony was used in ancient Egypt?
2. … how antimony was used by monks?
3. … how toxic antimony is?
4. … what application antimony has today?
5. … what the problem is with antimony?

Gallium
1. I would like to know what the melting point of gallium is?
2. … where gallium will transition into its liquid state?
3. … how toxic gallium is?
4. … what happens when you remove gallium form your hands?
5. … what a popular prank among scientists in the 1920s was?

Curium
1. Do you know who curium was named in honor to?
2. … why this element is so bizarre?
3. … why NASA has been using curium?
4. … why many have attempted to use curium in pacemakers?
5. … what the problem is with using curium in pacemakers?

Handout 29
1. Could you tell me when lutetium was discovered?
2. Do you know why lutetium is so rare?
3. Do you have any idea where technetium has been located?
4. I would like to know how technetium can be created.
5. Could you tell me what the key ingredient behind computer chips is?
6. Do you know where the biggest technology firms in the world are?
7. Do you have any idea where gallium will transition into its liquid state?
8. I would like to know how toxic gallium is.

Unit 2 Lesson 3 Handout 30 Oses

Instructions: Watch the video "The Simple Summary," and complete the following information.

1. What is summarizing?_____

2. Why is summarizing important?_____

3. The following are the basic steps to summarize:

3.1 Step 1: _____in five words or less.

3.2 Step 2: _____in five words or less.

3.3 Step 3: _____in five words or less.

3.4 Step 4: _____in five words or less.

3.5 Step 5:_____in five words or less.

3.6 Step 6:_____in five words or less.

Useful Language	
Could you tell me what answer you wrote in number X?	Sure! I wrote…
What step do you have in number X?	I have …
I would like to know what you wrote in number X.	Well, I wrote…

Unit 2 Lesson 3 Handout 31 Oses

Instructions: Watch the video "Paraphrasing: The Basic Steps," and complete the following information.

1. What is to paraphrase? Paraphrasing means _____into _____

2. Steps to paraphrase

2.1_____

2.2_____

2.3_____

2.4 Return to rewrite in your _____ _____. Make sure to change _____

and _____ as necessary.

Useful Language	
Could you tell me what you wrote in number X?	Sure! I wrote…
What step do you have in number X?	I have …
I would like to know what you wrote in number X.	Well, I wrote…
Could you repeat it, please?	No problem. It is..

Unit 2 Lesson 3 Handout 32 Oses

Instructions: Watch the video "The functional group concept explained" to answer the following questions.

Functional Groups

1. What is organic chemistry? Organic chemistry is _____.

2. What are hydrocarbons?

   Hydrocarbons are _____ made of _____and _____ only.

3. What is the simplest hydrocarbon? The simplest hydrocarbon is _____.

4. What does methane consist of?

   It consists of one _____ with four _____ _____ to _____ atoms.

5. What are alkenes?

   Alkenes are _____ that contain a double covalent _____ between two carbon

   _____ in the _____.

6. What are functional groups?

   Functional groups are groups of _____ which give _____ similar _____

Useful Language	
Do you know what…	Yes, I do. It is…. / They are…
Do you have any idea what…	Yes, I do. It is…. / They are…

Unit 2 Lesson 3 Handout 33 Oses

Instructions: Watch the video "The functional group concept explained" to complete this graphic organizer.

Functional Groups			
1. Alkanes	**2. Alkenes**	**3. Alcohol**	**4. Carboxylic Acid**
1.1 Methane	2.1_____	3.1_____	4.1_____
1.2_____	2.2 Propene	3.2 _____	4.2 _____
1.3_____	2.3 _____	3.3 Propanol	4.3 _____
1.4_____		3.4 _____	4.4 Butanoic acid
5. _____	6. _____	7. _____	

Useful Language

May I know what you have in number X? I have…
What did you write in number X? I wrote…
I would like to know what example(s) you wrote in number X. It is… / They are…

Unit 2 Lesson 3 Handout 34 Oses

Instructions: Summarize and restate the information given about examples of alkanes and alkenes. Use **six** main ideas at least.

1._____

2._____

3._____

4._____

5._____

6._____

7._____

8._____

9._____

10._____

Useful Language

Good evening
My name is…
I am from…
It is a great pleasure to be here.
I am going to share some facts about…

INFORMATION

To conclude, I want to say that…
Thanks for your attention.

Unit 2 Lesson 3 Handout 35 Oses

Instructions: Complete the following words with the underlined ending in each head word.

1. Alk**ane**	2. Alk**ene**	3. Alcoh**ol**	4. Carboxyl**ic** acid
1.1 meth____	2.1 meth____	3.1 methan____	4.1 methano____ acid
1.2 eth____	2,2 eth____	3.2 ethan____	4.2 ethano____ acid
1.3 prop____	2.3 prop____	3.3 propan____	4.3 propano____ acid
1.4 but____	2.4 but____	3.4 butan____	4.4 butano_____ acid

Useful Language	
I would like to know what you have in the functional group called …	Sure! I have…
Could you read the words that you have in the column named…	The words are…

Unit 2 Lesson 3 Answer Key

Handout 30

1. Summarizing is giving a short statement of the important points.
2. Summarizing allows you to restate key information in a way that is short and in order.

3.1 Step 1: who was in this story	3.2 Step 2: what happened in this story	3.3 Step 3: when it happened
3.4 Step 4: where it happened	3.5 Step 5: why it happened	3.6 Step 6: how it happened

Handout 31

1. Paraphrasing means **putting other people's words** into **your own words**.

2.1 Read carefully.	2.2 Make sure you understand.	2.3 Go away and take a break.

2.4 Return to rewrite in your **own words**. Make sure to change **grammar** and **vocabulary** as necessary.

Handout 32

1. Organic chemistry is the study of carbon compounds.
2. Hydrocarbons are compounds made of hydrogen and carbon only.
3. The simplest hydrocarbon is methane.
4. It consists of one carbon with four covalent bonds to hydrogen atoms.
5. Alkenes are hydrocarbons that contain a double covalent bond between two carbon atoms in the molecule.
6. Functional groups are groups of atoms which give molecules similar properties.

Handout 33

1. Alkanes:	1.1 Methane	1.2 Ethane	1.3 Propane	1.4 Butane
2. Alkenes :	2.1 Ethene	2.2 Propene	2.3 Butene	
3. Alcohol:	3.1 Methanol	3.2 Ethanol	3.3 Propanol	3.4 Butanol
4. Carboxylic Acid:	4.1 methanoic acid	4.2 Ethanoic acid	4.3 Propanoic acid	4.4 Butanoic acid
5. Esters	6. Ketones	7. Amines		

Handout 35

1.1 Methane	1.2 Ethane	1.3 Propane	1.4 Butane
2.1 Methene	2.2 Ethene	2.3 Propene	2.4 Butene
3.1 Methanol	3.2 Ethanol	3.3 Propanol	3.4 Butanol
4.1 methanoic	4.2 Ethanoic	4.3 Propanoic	4.4 Butanoic

Instructions: Write down five questions to ask for opinions and phrases to introduce an opinion from the videos.

Questions to ask for an opinion

1. _____

_____

2._____

_____

3._____

_____

4. _____

_____

5. _____

_____

Phrases to introduce an opinion

1._____

2._____

3._____

4._____

5._____

6._____

7._____

8._____

9._____

10._____

11._____

12._____

Unit 2 Lesson 4 Handout 37 Oses

Instructions: Complete the following list of words with the ones that you and your classmates selected.

1. The Haber-Bosch Process

1.1_____

1.2_____

1.3_____

2. Silicon

2.1_____

2.2_____

2.3_____

3. Saponification:

3.1_____

3.2_____

3.3_____

4. Fermentation

4.1_____

4.2_____

4.3_____

5. Bronze

5.1_____

5.2_____

5.3_____

6. Maillard Reaction

6.1_____

6.2_____

6.3_____

Useful Language

What is the pronunciation of word X?
How do you pronounce word X?

Unit 2 Lesson 4 Answer Key

Handout 36

Questions to ask for an opinion

1. What is your opinion on…?
2. What are your thoughts on…?
3. What do you think about…?
4. What's your take on…?
5. What are your initial thoughts on…?

Phrases to introduce an opinion

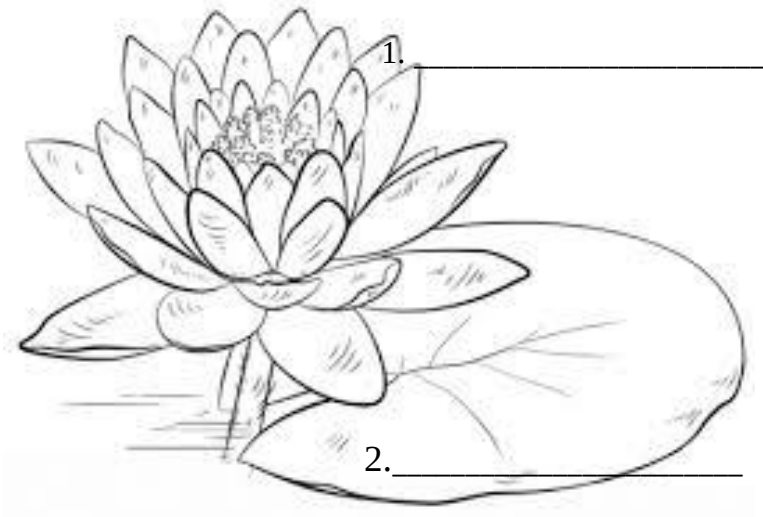
1. I think…
2. I believe…
3. I feel…
4. I suppose…
5. I guess…
6. In my opinion,
7. In my view,
8. From my viewpoint,
9. From my point of view,
10. From my perspective,
11. According to me,
12. It seems to me that…

Handout 37

1. **The Haber-Bosch Process:** Nitrogen – nitrates – chemist – process - hydrogen
2. **Silicon:** silicon – solid - mass - crystals - semiconductor
3. **Saponification:** formulas - alkali – triglycerides – glycerol - molecule – base - polar
4. **Fermentation:** Fermentation - acids – alcohol – gas – alcoholic
5. **Bronze:** Metal - chemistry – copper – gold – silver – platinum - alloying - iron
6. **Maillard Reaction:** Sugars - amino – acids – temperatures – compounds – reaction

Unit 2 Assessment Lesson Handout 38

Part I.
Instructions: Label the parts of the picture and the definition with these three words: Lotus flower, Lotus leaf, Foul



1. _____

2. _____

3. _____= dirty, muddy

Part II.
Instructions: Watch the video "Hydrophobic Surfaces," and write down three applications of hydrophobic surfaces.

1. _____

2. _____

3. _____

Useful Language	
In Part X, what do you have in number X?	I have… / I wrote…

Unit 2 Assessment Lesson Handout 39

Instructions: Read the following text.

Wettability

Wetting of solid surfaces by liquid materials is an important aspect of materials science and surface chemistry, and in clues in practical applications in everyday life and industry. Ideally, once a drop is placed on a surface, it forms a sphere or wets the surface completely. The first and second cases are called antiwetting and super wetting, respectively (Durand et al., 2011). In wetting studies, usually the contact angle is one of the most important data showing the amount of the wetting value when a liquid and solid are in contact with each other. Consider a drop of liquid placed on a horizontal surface (Fig. 1). The contact angle is defined as the angle formed by the intersection of the solid, liquid, and solid-gas interface. Fig. 1 shows that the small contact angle is formed when the liquid is distributed on the surface, while large contact angles are formed when there is lower contact area between solid and liquid (Yuan and Lee, 2013).

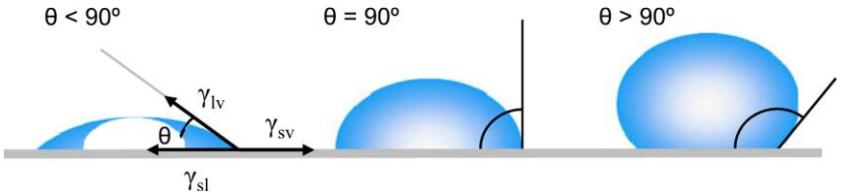


Fig. 1 Illustration of contact angles formed by sessile liquid drops on a smooth homogeneous solid surface (Yuan and Lee, 2013).

Wettability. Text taken from: Barati, Gh., Aliofkhazraei, M., Khorsand, S., Sokhanvar, S., Kaboli; A. (2018). Science and Engineering of Superhydrophobic Surfaces: Review of Corrosion Resistance, Chemical and Mechanical Stability. Arabian Journal of Chemistry. In Press.

1. Instructions: Write down these two questions **directly**. You want to know

1.1 the reason why wetting is important._____

1.2 what contact angles show in wetting studies._____

Useful Language
What question did you write in number X? / What did you write in number X? I wrote…

2. Instructions: Write the previous questions **indirectly**.

2.1 _____

2.2 _____

Useful Language
-Could you tell me how you wrote the question X? -Sure! I wrote…

3. Instructions: Summarize the previous text.

_____

_____

_____

_____

Useful Language
-I would like to know how you summarized the text. -No problem. I wrote….

4. Instructions: Form your viewpoint, why is wettability important to be studied?

_____

_____

_____

_____

_____

Useful Language
- May I know what your point of view is? - I think that … - In my opinion, … - It seems to me that…

Unit 2 Assessment Lesson Handout 40

UNIT 2 ASSESSMENT TASK

Total points: 20 Obtained Points: ____ Score: _____ Percentage: 25 % / ____

Student's name: _____ **Date:** October 17, 2018.

1. Instructions: You were invited to a conference as a listener. Watch the video "The Hydrophobic Effect" to ask the following questions **directly**. 5 pts. / _____

You want to know
1. a definition of hydrophobic effect.
2. the reason why salt dissolves in water.
3. characteristics of polar molecules.
4. what two nonpolar molecules tend to do when they are put in water.
5. the reason why polar things tend to be attracted if they are not charged.

1.1 _____

1.2 _____

1.3 _____

1.4 _____

1.5 _____

2. Instructions: Watch the video "The Hydrophobic Effect" to ask the following questions **indirectly**. 5 pts. / _____

You want to know

1. a definition of entropy.
2. the reason why the universe is always moving towards disorder.
3. how entrophy is related to hydrophobic effect.
4. what happens when two oil drops move towards one another.
5. an example of a biological structure that uses the hydrophobic effect.

2.1_____

2.2 _____

2.3 _____

2.4 _____

2.5 _____

3. Instructions: Answer these questions orally. 10 pts. / _____

3.1 Could you summarize and paraphrase the information from the two videos?

_____

_____

_____

_____

_____

3.2 What is your opinion about hydrophobic materials?

_____

_____

_____

_____

_____

Unit 2 Assessment Lesson Answer Key

Handout 38:

Part I.
1.Lotus flower
2. Lotus leaf
3. Foul

Part II.
1. Self-cleaning materials
2. Antifouling materials
3. Problem of ice

Handout 39:
1.1 Why is wetting important?
1.2 What do contact angles show in wetting studies?
2.1 Could you tell me why wetting is important?
2.2 Do you know what the two forms of wetting are?

3. Possible Summary:

Wetting surfaces is important in surface chemistry. Antiwetting and superwetting are forms a drop behaves on a surface. The contact angle shows wetting value: small angles are formed when liquids are spread on the surface; large contact angles mean lower contact area.

Handout 40:
1.1 What is hydrophobic effect?
1.2 Why does salt dissolve in water?
1.3 What are characteristics of polar molecules?
1.4 What do two nonpolar molecules tend to do when they are put in water?
1.5 Why do non polar things tend to be attracted if they are not charged?

2.1 Could you tell me what entropy is?
2.2 I would like to know why the universe is always moving towards disorder.
2.3 Could you tell me how entrophy is related to hydrophobic effect?
2.4 May I know what happens when two oil drops move towards one another?
2.5 Could you tell me an example of a biological structure that uses the hydrophobic effect?

Instructions: Complete the following list of tips about public speaking with information from the video clip "How to Give a Speech."

7 Tips for Successful Public Speaking

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____ that it won't _____ the way you expect it to go

7. _____ and _____ from your _____

Useful language	
What tip did you write in number X?	I wrote…
What tip is easy to use for you?	Tip X is easy to use because…
What tip is difficult to use for you?	Tip X is difficult for me because…

Unit 3 Lesson 1 Handout 42 Oses

Instructions: Complete the following graphic organizer using information from the video "Titanium Element."

Physical Properties

1._____ 2. _____ 3. Density:_____ grams per cm^3

4._____ 5. Texture: _____ 6. _____

7. At room temperature, it is _____ 8. Its luster is _____

Uses

1._____

2. _____

3. _____

TITANIUM

Chemical Properties

1._____

2. _____

3. _____

Disadvantages

1. Melting point: _____ 2. Boiling point: _____

3._____ 4. _____

Unit 3 Lesson 1 Handout 43 Oses

Instructions: Complete the following graphic organizer using information from the video "Titanium: Periodic table of Videos."

Titanium

Characteristics

1._____ 2._____

3._____ 4._____

5._____ 6._____

7. Problem at high temperatures in oxygen: _____

Titanium Dioxide

1. Places to get to titanium dioxide:_____

2. Problem to make titanium metal:_____

3. Color:_____

4. Problem with titanium tetrachloride TiCl4: if you just leave it as titanium tetrachloride, in the _____, it will _____ with the air, with _____ in the air, and go back to titanium _____.

Uses of Titanium

1. It's used in _____

2. Additive for _____

3. It is often used in the construction of_____

4. You often use titanium for_____

5:_____

6. One of the most interesting applications of titanium is as a _____

Useful Language	
What physical properties did you write?	I wrote…
What disadvantages do you have?	I have…
About titanium dioxide, what can you tell me about …	I can tell you that

Unit 3 Lesson 1 Handout 44 Oses

Instructions: Read the following information. Then, combine the possible events and consequences to form conditionals.

Conditionals	**Possible event** Combine titanium and aluminium	**Consequence** Get a good alloy
	<u>If you</u> combine titanium and aluminium, **<u>you will</u>** get a good alloy **<u>If you</u>** combine titanium and aluminum, **<u>you get</u>** a good alloy	

Possible Event	**Consequence**
1. put titanium in at high temperatures in oxygen	it will burn.
2. build a fighter aircraft you need to be pretty light	you will use titanium alloys.
3. use steel to do experiments in a high magnetic field	your apparatus will be pulled away by the magnet.
4. look around the room you're in	almost certainly the walls are white with titanium dioxide.

1._____

2._____

3._____

4._____

Useful language	
What sentence did you write in number X?	I wrote…
What sentence do you have in number X?	I have…

Unit 3 Lesson 1 Answer Key

Handout 41: 1. Practice 2. Have a structure 3. Repeat Yourself 4. Use transitions 5. Humanize yourself 6. Accept that it won't go the way you expect it to go 7. Study and learn from your mistakes

Handout 42:

Physical Properties:

1. Strong 2. Light 3. Density of 4.5 grams per cm^3 4. It doesn't corrode. 5. Its texture is smooth.
6. Its hardness is six. 7. At room temperature, it is a solid. 8. Its luster is metallic.

Uses: 1. Jets like the lock head 2. computer components 3. missiles

Chemical Properties: 1. Atomic number is 22. 2. Atomic mass is 47.8. 3. It has two valence electrons.

Disadvantages:

1. Melting point is over 1668 Celsius. 2. Boiling point is over 3287 Celsius. 3. Titanium is malleable when heated.
4. Titanium is very expensive.

Handout 43:

1.Titanium is lightweight. 2. It's strong. 3. It does not react with water. 4. It's non-magnetic.

5. It's very abundant on the planet. 6. It has a dark coloration 7. It burns

Titanium dioxide

1. Places to get to titanium dioxide: various places across the world.
2. Problem to make titanium metal: titanium atoms bond strongly to the oxygen and it's difficult to get them apart.
3. Color: white powder
4. Problem with titanium tetrachloride TiCl4: if you just leave it as titanium tetrachloride, in the air, it will react with the air with water in the air, and go back to titanium dioxide.

Uses of titanium

1. It's used in construction materials.
2. Additive for alloys.
3. Often used as well in the construction of aerospace all sort of capsules and components to go into space
4. You often use titanium for very high-pressure applications.
5. Hip implants.
6. One of the most interesting applications of titanium is as a catalyst for making polythene.

Handout 44

1. If you put titanium in at high temperatures in oxygen, it will burn.
2. If you build fighter aircraft you need to be pretty light, you will use titanium alloys.
3. If you use steel to do experiments in a high magnetic field, your apparatus will be pulled away by the magnet.
4. If you look around the room you're in, almost certainly the walls are white with titanium dioxide.

Unit 3 Lesson 2 Handout 45 Oses

Instructions: According to the video, match the name and the description of the following theories of life.

Theories of Life

Chemical Evolution Theory - Spontaneous Generation - Panspermia

1. _____: according to ancient Greeks units of life called spores transferred to earth.

2. _____: believes life aroused from rotting and decayed material but spontaneous generation was turned down by Louis Pasteur's experiments

3. _____: First form life could have come from preexisting nonliving organic molecules, RNA-protein

Useful Language	
What theory did you write in number X?	I wrote…
What do you have in number X?	I have…
Which theory do you agree the most and why?	I think I agree with … because…

Instructions: Watch the video and make a list of four tips about body language.

4 Essential Body Language Tips

Great speakers

1. _____

2. _____

3. _____

4. _____

Useful language	
What tip did you write in number X?	I wrote…
What do you have in number X?	I have…
Which tip could you use easily?	I think I can …

Unit 3 Lesson 2 Handout 47 Oses

Instructions: Watch the video "What are CHNOPS?" and make a list of six elements of life.

Elements of Life

1. C_____

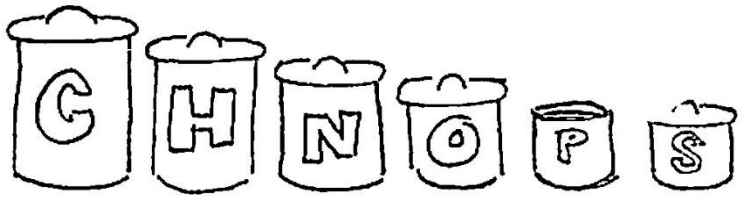
2. H_____

3. N_____

4. O_____

5. P_____

6. S_____



Useful Language	
What did you write in number X?	I wrote…
What do you have in number X?	I have…

Unit 3 Lesson 2 Handout 48 Oses

Instructions: Read the following information.

Discourse markers are words or phrases to connect, organize and, manage what we say or write or to express attitude. The next ones are some examples.

To contrast: Nonetheless - However

To add information: Moreover - Furthermore

To show result: Consequently - Therefore

To Emphasize: Indeed - In fact

To exemplify: For instance

To show similarity: Likewise - Correspondingly

Instructions: Complete the passage using discourse markers to show the next purposes.

1. To add information 2. To show results 3. To show results

1. Carbon is about 18% of humans, by mass. We say Earth has carbon-based life-forms. Why do we say that? Because of the carbon backbone. (1) _____, carbon makes up the skeleton of most biological molecules, including proteins, carbohydrates, lipids, and nucleic acids. Carbon has four valence electrons; (2)_____, this lets it make a variety of bonds. Four single bonds, two double bonds, a single bond, and a triple bond. (3)_____, you can make lots of different stable structures. Imagine if we were talking about Legos or tinker toys. If you can join together pieces in four different ways, you could make a lot more structures than something with only one connection or two connections.

Useful Language	
In number X, I wrote… Is it OK?	Could you help me with number X? I am not sure about it!

Instructions: Read the following information.

Discourse markers are words or phrases to connect, organize and, manage what we say or write or to express attitude. The next ones are some examples.

To contrast: Nonetheless - However

To add information: Moreover - Furthermore

To show result: Consequently - Therefore

To Emphasize: Indeed - In fact

To exemplify: For instance

To show similarity: Likewise - Correspondingly

Instructions: Complete the passage using discourse markers to show the next purposes.

1. To show result 2. To Emphasize 3. To show result

2. Hydrogen makes up about 10% of humans. We find hydrogen in water, H_2O; (1)_____, it's not surprising it makes up so much of living matter. We're about 60% water. (2)_____, some organisms are as much as 90% water. Hydrogen is especially active in its ionic form H+. Acids increase H+ concentration while bases decrease H+ concentration; _____, hydrogen plays an important part in acid-base behavior, which is involved in a lot of biochemical reactions.

Useful Language

In number X, I wrote… Is it OK? Could you help me with number X? I am not sure about it!

Unit 3 Lesson 2 Handout 48 Oses

Instructions: Read the following information.

Discourse markers are words or phrases to connect, organize and, manage what we say or write or to express attitude. The next ones are some examples.

To contrast: Nonetheless - However

To add information: Moreover - Furthermore

To show result: Consequently - Therefore

To Emphasize: Indeed - In fact

To exemplify: For instance

To show similarity: Likewise - Correspondingly

Instructions: Complete the passage using discourse markers to show the next purposes.

1. To exemplify 2. To Emphasize 3. To add information

3. Nitrogen is an essential component of DNA. (1)_____, think of those nitrogenous bases that make up the rungs of the DNA ladder. Also be on the lookout for nitrogen in immune groups, like on the ends of amino acids. These amine groups confer basic (as opposed to acidic) behavior. (2)_____, nitrogen makes up about 3% of humans. (3)_____, nitrogen is also especially abundant in the air that we breathe, about 78%.

Useful Language

In number X, I wrote… Is it OK? Could you help me with number X? I am not sure about it!

Unit 3 Lesson 2 Handout 48 Oses

Instructions: Read the following information.

Discourse markers are words or phrases to connect, organize and, manage what we say or write or to express attitude. The next ones are some examples.

To contrast: Nonetheless - However

To add information: Moreover - Furthermore

To show result: Consequently - Therefore

To Emphasize: Indeed - In fact

To exemplify: For instance

To show similarity: Likewise - Correspondingly

Instructions: Complete the passage using discourse markers to show the next purposes.

1. To show result 2. To add information 3. To Emphasize

4. Oxygen is also found in water, H_2O. (1)_____, you'd expect a lot of oxygen in living matter. Oxygen makes up about 65%, by mass, of the human body. (2)_____, we also breathe oxygen, O_2. In chemistry, oxygen is important in oxidizing reactions. It's going to grab electrons and become negatively charged. (3)_____, some people think antioxidants are important to slow down our internal oxidizing, or rusting, if you will.

Useful Language

In number X, I wrote… Is it OK? Could you help me with number X? I am not sure about it!

Unit 3 Lesson 2 Handout 48 Oses

Instructions: Read the following information.

Discourse markers are words or phrases to connect, organize and, manage what we say or write or to express attitude. The next ones are some examples.

To contrast: Nonetheless - However

To add information: Moreover - Furthermore

To show result: Consequently - Therefore

To Emphasize: Indeed - In fact

To exemplify: For instance

To show similarity: Likewise - Correspondingly

Instructions: Complete the passage using discourse markers to show the next purposes.

1. To add information 2. To show similarity 3. To add information

5. Phosphorus is found in the backbone of DNA. Remember the backbone goes "sugar-phosphate-sugar-phosphate." (1)_____, we find those phosphate groups in ATP which is the key form of energy currency in biochemical reactions. (2)_____, phosphorylation and dephosphorylation events are really important in biochemistry. This is often used as a signal or as a trigger for conformational changes in biological molecules. (3) _____, we also find phosphates in phospholipids, which are an important part of cell membranes. Phosphorus makes up about 1% of humans.

Useful Language	
In number X, I wrote… Is it OK?	Could you help me with number X? I am not sure about it!

Unit 3 Lesson 2 Handout 48 Oses

Instructions: Read the following information.

Discourse markers are words or phrases to connect, organize and, manage what we say or write or to express attitude. The next ones are some examples.

To contrast: Nonetheless - However

To add information: Moreover - Furthermore

To show result: Consequently - Therefore

To Emphasize: Indeed - In fact

To exemplify: For instance

To show similarity: Likewise - Correspondingly

Instructions: Complete the passage using discourse markers to show the next purposes.

1. To add information 2. To add information 3. To contrast

6. Sulfur is found in 2 amino acids, cysteine and methionine. You'll learn that amino acids string together to form proteins; (1) _____, these are two of the 20 amino acids. The sulfurs from these amino acids tend to bind together, forming disulfide bridges. This is part of what holds a folded protein together in its final 3D shape. (2)_____, a few organisms use selenium instead of sulfur. (3)_____, for most organisms, it's a fundamental part of what makes us, 0.25% of humans are sulfur.

Useful Language

In number X, I wrote… Is it OK? Could you help me with number X? I am not sure about it!

Unit 3 Lesson 2 Handout 49 Oses

Instructions: Read the following sentences and classify the highlighted discourse markers according to the function that they have.

1. Carbon has four valence electrons; **therefore**, this lets it make a variety of bonds.

2. We're about 60% water. **In fact**, some organisms are as much as 90% water.

3. Nitrogen is an essential component of DNA. **For instance**, think of those nitrogenous bases that make up the rungs of the DNA ladder.

4. Oxygen makes up about 65%, by mass, of the human body. **Furthermore**, we also breathe oxygen, O2.

5. We find those phosphate groups in ATP which is the key form of energy currency in biochemical reactions. **Correspondingly**, phosphorylation and dephosphorylation events are really important in biochemistry.

6. A few organisms use selenium instead of sulfur. **Nonetheless**, for most organisms, it's a fundamental part.

1._____ 2._____ 3._____

4._____ 5._____ 6._____

Useful Language	
How did you classify the discourse marker in sentence X?	I think it is to…
What function is the discourse marker doing in sentence X?	It is …

Unit 3 Lesson 2 Answer Key

Handout 45

1. Panspermia 2. Spontaneous generation 3. Chemical Evolution Theory

Handout 46

1. keep their body open. 2. have their palms open 3. get comfortable with the stage 4. Don't touch the podium.

Handout 47

1. Carbon 2. Hydrogen 3. Nitrogen 4. Oxygen 5. Phosphorus 6. Sulfur

Handout 48

1. Carbon:	1. Moreover – Furthermore	2. Consequently - Therefore	3. Consequently - Therefore
2. Hydrogen:	1. consequently - therefore	2. Indeed - In fact	3. Consequently - Therefore
3. Nitrogen:	1. For instance	2. Indeed - In fact	3. Moreover – Furthermore
4. Oxygen:	1. Consequently - Therefore	2. Moreover - Furthermore	3. Indeed - In fact
5. Phosphorus:	1. Moreover - Furthermore	2. Likewise - Correspondingly	3. Likewise - Correspondingly
6. Sulfur:	1. Moreover - Furthermore	2. Moreover - Furthermore	3. Nonetheless - However

Handout 49

1. To show result 2. To show emphasis 3. To exemplify
4. To add information 5. To show similarity 6. To show contrast

Instructions: Watch the video "Public Speaking Eye Contact" to answer the following questions about eye contact.

Making Good Eye Contact in Presentations

1. What to do? _____

2. How long? _____

3. What is the goal? _____

Useful Language	
What did you write in number X?	I wrote…
What answer do you have in number X?	I have…
Is eye contact easy for you? Why?	It is easy because…
	It isn't easy because…

Instructions: Watch the video "How to Handle Questions from Audience" to answer the following questions.

How to Handle Questions from Audience

1. What should you do if participants ask you a question after or during a presentation?

1. _____

2. What are two tips to answer questions?

2.1 _____ 2.2 _____

3. What should you do if you are asked a question you don't know?

3.1 Say _____

Vocabulary
Flustered = embarrased

3.2 If you can find the answer out, say _____

Useful Language	
What did you write in number X?	I wrote…
What answer do you have in number X?	I have…

Unit 3 Lesson 3 Handout 52 Oses

Instructions: Write down the question to each of the following answers. Then watch the video "Professor Frances Arnold (EuChemS2018 plenary speaker)." to check your match.

1. _____

Oh! I'd love to. Chemists are inspired and awed by the biological world, but what they really should be inspired by is the process by which biology discovers chemistry. That's called evolution, so I practice evolution in the laboratory. I breed molecules like you breed cats and dogs, and I make interesting new things that do chemistry.

2. _____

So, I'm going to explain how we can evolve enzymes; these amazing catalysts that biology has, to do chemistry that was invented by humans, not by Nature, and this, as I say, this marvelous process by which innovation happens in the biological world, I contain that in the laboratory, and I can make enzymes that catalyze wonderful reactions, making molecules that chemists have a very hard time making.

3. _____ It is.

4. _____ So far it's so great.

5. _____

Oh! I plan to go to as many as I can, starting with the ones that the great talks yesterday, Carol Robinson and Ben Farina, and I'm going to get lots of new ideas

6. _____

It is absolutely really time, especially to be in the biological chemistry interface.

Useful Language	
I think this question matches answer X.	This question should be in answer X.
You are wrong. This one is to answer X.	You're correct. These two match.

Unit 3 Lesson 3 Handout 53 Oses

Instructions: Read the following information about the simple past tense.

In Simple Past Tense

1. What **was** the prize motivation? Was - were No other verb
   I - he - she - it ► was You – we – they ► were

2. When **did** she **receive** the award? Did + other verb in the simple form

Instructions: Complete the following questions with was or did.

1. How many times _____ Marie Curie win the award?
2. What mineral _____ more radioactive than uranium?
3. How _____ they discover a new kind of radiation?
4. What _____ the pair discover about the aluminum radiation?
5. How _____ they use the method in 1930s?
6. What _____ the method used for?
7. What _____ she do in 1970?
8. What _____ she use to map the structure of ribosomes?
9. What _____ Frances and her team think?
10. What _____ the prize motivation?

Useful Language	
What did you write in number X?	I wrote…
What do you have in number X?	I have…

Unit 3 Lesson 3 Answer Key

Handout 50

1. to make direct eye contact 99 % of the time
2. long enough to finish a sentence
3. to look at every single person in the room

Handout 51

1. Don’t panic

2.1 You got to really listen carefully	2.2 Answer the question the best you can
3.1 Say you don’t know the answer	3.2Say you email the answer later.

Handout 52

1. Let's talk a little bit about your research and some of the key applications involved in it.
2. Tell me a little bit about the plenary talk you'll be giving here.
3. Is this your first EuCheMS congress?
4. Are you enjoying it so far?
5. What are some of the highlights of all the different plenary talks that you can see going on?
6. Is this an exciting time for chemistry?

Handout 53

1. did	2. Was	3. Did	4. Did	5. Did
6. Was	7. Did	8. Did	9. Did	10. Was

Instructions: Watch the video "What is the Maillard Reaction?" and match columns A and B.

COLUMN A	**COLUMN B**
1. The French chemist Louis Camille Maillard	( ) are oxygen containing compounds that have a nutty or sweet taste.
2. The specific compounds that you end up with	( ) described how sugars and amino acids will combine to create aromatic compounds that also happen to pack a lot of flavor.
3. Thiophenes	( ) makes meats taste meatier, sweets sweetier, and salts saltier.
4. Oxazoles	( ) depend on cooking time and temperature as well as the kinds of sugars and amino acids that you add to the reaction.
5. Alapyridaine	( ) tastes so delicious.
6. The chemical combination of sugar, protein and heat	( ) are sulfur containing compounds that have a distinctly meaty quality.

Useful Language	
How did you match the columns?	My number sequence is…
I am sorry! What did you match number X with?	I matched it with…

Unit 3 Assessment Lesson Handout 55 Oses

Instructions: Watch the video "Browning Reactions in Foods Animation." and fill in the blanks.

BROWNING REACTIONS

(1)_____ is an undesirable reaction that is responsible for the discoloration observed in some fresh-cut fruits and vegetables.

When the fruit or vegetable is cut or bruised, the (2) _____ substrates and the (3) _____ oxidase enzymes can come together and react in the presence of oxygen over time to produce undesirable brown colored compounds.

(4) _____is responsible for the development of many pleasant and desirable aromas and flavors and foods. There are two main types of non-enzymatic browning reactions, the (5) _____ and (6)_____.

Maillard reation begins with a reaction between the (7) _____ of one reducing sugar such as (8) _____ and a free amino group from an amino acids such as (9) _____ or from a protein to produce N-glycosylamine. Once the initial Maillard reaction begins, a cascade of additional reactions takes place, eventually forming brown nitrogen.

Carmelization is a complex series of chemical reactions that occur when a sugar is heated to a temperature greater than its (10) _____. The high temperature heating causes a series of reactions that (11) _____, decompose, and (12) _____ the sucrose molecules resulting in the formation of caramel colored and flavored compounds.

Useful Language

What did you write in number X. I wrote … What word do you have in number X? I have…

Instructions: Watch the pictures to label the following definitions.

1. _____ = to burn or char the surface of

2. _____ = fraudulent

3. _____ = an egg that has been cooked, outside the shell, by poaching. This method of preparation is favored for eggs, as it can give more delicately cooked eggs than cooking at higher temperatures such as with boiling water.

4. _____ = broad, shallow container of metal, usually having sides flaring outward toward the top, used in various forms for frying, baking, washing, etc.

5. _____ = a container of earthenware, metal, etc., usually round and deep and having a handle or handles andoften a lid, used for cooking, serving, and other purposes.

6. _____ = any of the clusters of bulbous nerve endings on the tongue and in the lining of the mouth that provide the sense of taste.

7. _____ = having the potential to cause cancer.

8. _____ = a white, tasteless, solid carbohydrate, (C6H10O5)n

9. _____ = explode

10. _____ = want greatly; desire eagerly

Useful language	
What word did you write in number X?	I wrote…
What do you have in number X?	I have…
How did you complete item X?	I wrote…

Instructions: Write the word next to its pronunciation. Then practice the pronunciation.

glycosylamine	**ketosamine**	**pyrolysis**	**acrylamide**	**caramelization**

1. / glaɪ kə ˈsɪ lə mɪn / _____

2. / ki ˈtoʊ sə mɪn / _____

3. / paɪ ˈrɒ lə sɪs / _____

4. / kɒ rə mɛ lə ˈzeɪ ʃən / /kɒr mɛ lə ˈzeɪ ʃən / _____

5. / ə ˈkrɪ lə mɪd/ / æ krə ˈlæ mɪd/ / ə ˈkrɪ lə maɪd/ / æ krə ˈlæ maɪd / _____

Useful Language	
What word did you write in number X?	I wrote…
How do you pronounce word X?	I say…

Assessment Lesson Unit 3 Answer Key

Handout 54 4 - 1 - 5 - 2 - 6 - 3

1. The French chemist Louis Camille Maillard in 1912 described how sugars and amino acids will combine to create aromatic compounds that also happen to pack a lot of flavor.

2. The specific compounds that you end up with depend on cooking time and temperature as well as the kinds of sugars and amino acids that you add to the reaction.

3. Thiophenes are sulfur containing compounds that have a distinctly meaty quality.

4. Oxazoles are oxygen containing compounds that have a nutty or sweet taste.

5. Alapyridaine makes meats taste meatier, sweets sweetier, and salts saltier.

6. The chemical combination of sugar, protein and heat tastes so delicious.

Handout 55

1.Enzymatic Browning	2. Phenolic	3. Polyphenol	4. Non-Enzymatic Browning
5. Maillard reaction	6. Carmelization	7. carbonyl group	8. Glucose
9. Lysine	10. melting point	11. Dehydrate	12. Polymerize

Handout 56

1. sear	2. deceptive	3. Poached egg	4. pan	5. Pot
6. Taste bud	7. carcinogenic	8. Starch	9. burst	10. crave

Handout 57

1. glycosylamine	2. ketosamine	3. pyrolysis	4. acrylamide	5. caramelization

Appendix N

List of words from Unit 1: Listening to Chemists

1. allotrope
2. anhydrase
3. biomimicry
4. bond
5. catalysis
6. cation
7. chemistry
8. coalesce
9. collide
10. covalent
11. decarboxylation
12. dioxide
13. dissociate
14. electron
15. enol
16. enzyme
17. fullerene
18. halide
19. keto
20. lattice
21. molecule
22. polymerase
23. shell
24. stoichiometry
25. tautomerize

List of words from Unit 2: Asking for Chemistry Information

1. alcohol
2. alkali
3. alkane
4. alkene
5. alloy
6. amine
7. anisotropic
8. antimony
9. bismuth
10. bronze
11. carboxylic
12. compound
13. copper
14. curium
15. ethanol
16. formula
17. francium
18. gallium
19. isotropic
20. lutetium
21. matter
22. methane
23. nitrate
24. polar
25. process
26. propanoic
27. reaction
28. sample
29. saponify
30. silicon
31. solid
32. technetium
33. triglyceride
34. volume
35. weigh

List of words from Unit 3: Interacting with Chemists

1. antioxidant
2. crystallography
3. cysteine
4. disulfide
5. luster
6. malleable
7. methionine
8. nitrogenous
9. oxidizing
10. phosphate
11. phosphorylation
12. pitchblende
13. polonium
15. radioactivity
15. radium
16. selenium
17. sulfur
18. tetrachloride
19. titanium
20. uranium

Appendix O
Word Analysis Instrument

Word: _____ Participant's Code:_____

1. Word stress

1.1.Was the word stress correctly placed? Yes: ____ No: ____

2. Vowel Sound

2.1 Was each vowel sound correctly pronounced? Yes:____ No: ____

2.2 If not, what was the vowel change?

2.2.1 /_____ / instead of /_____/ 2.2.2 /_____ / instead of /_____/

2.2.3 /_____ / instead of /_____/ 2.2.4 /_____ / instead of /_____/

3. Diphthong

3.1 Was each diphthong correctly pronounced? Yes: ____ No: ____

3,2 If not, what was the diphthong change?

3.2.1 /_____ / instead of /_____/ 3.2.2 /_____ / instead of /_____/

3.2.3 /_____ / instead of /_____/ 3.2.4 /_____ / instead of /_____/

4. Consonant Sound

4.1 Was each consonant sound correctly pronounced? Yes: ____ No: ____

4.2 If not, what was the change?

4.2.1 /_____ / instead of /_____/ 4.2.2 /_____ / instead of /_____/

4.2.3 /_____ / instead of /_____/ 4.2.4 /_____ / instead of /_____/

5. Insertion or deletion of sounds

5.1 Was an extra sound inserted? Yes: ____ No: ____

5.2 If yes, what was the sound? /____/, /____/, /____/

5.3 Was a sound deleted? Yes: ____ No: ____

5.4 If yes, what was the sound? /____/, /____/, /____/

Appendix P

O-Spelled Words Analysis Instrument

Word: _____ Participant's Code:_____

1. Was the word with the letter o correctly pronounced? Yes: ____ No: ____

2. If not, what was the pronunciation change?

    2.1 /o/ instead of /oʊ/ ____

    2.2 /o/ instead of /ɒ/ ____

    2.3 /ə/ instead of /oʊ/ ____

    2.4 /ə/ instead of /ɒ/ ____

    2.5 /o/ instead of /ə/ ____

    2.6 /ʊ/ instead of /ʌ/ ____

    2.7 /o/ instead of /ɔ/ ____

    2.8 /ɒ/ instead of /ɔ/ ____

    2.9 /ʌ/ instead of /oʊ/ ____

Appendix Q

Chemistry-Related Words with Diphthongs

1. alkali
2. alkane
3. allotrope
4. alloy
5. anhydrase
6. anisotropic
7. antimony
8. biomimicry
9. cation
10. coalesce
11. collide
12. compound
13. covalent
14. decarboxylation
15. dioxide
16. dissociate
17. disulfide
18. enzyme
19. halide
20. isotropic
21. keto
22. methane
23. methionine
24. nitrate
25. nitrogenous
26. oxidizing
27. phosphate
28. phosphorylation
29. polar
30. polonium
31. polymerase
32. process
33. propanoic
34. radioactivity
35. saponify
36. stoichiometry
37. tautomerize
38. tetrachloride
39. titanium
40. triglyceride
41. uranium

Appendix R

Words spelled with the letter “o”

1. alcohol
2. allotrope
3. alloy
4. anisotropic
5. antimony
6. antioxidant
7. biomimicry
8. bond
9. bronze
10. carboxylic
11. cation
12. coalesce
13. collide
14. compound
15. copper
16. covalent
17. crystallography
18. decarboxylation
19. dioxide
20. dissociate
21. electron
22. enol
23. ethanol
24. formula
25. isotropic
26. keto
27. methionine
28. molecule
29. nitrogenous
30. oxidizing
31. phosphate
32. phosphorylation
33. polar
34. polonium
35. polymerase
36. process
37. propanoic
38. radioactivity
39. saponify
40. silicon
41. solid
42. stoichiometry
43. tautomerize
44. tetrachloride
45. volume