

Chemistry 2202

Curriculum Guide 2018



Education and Early Childhood Development

***Department of Education and Early
Childhood Development
Mission Statement***

The Department of Education and Early Childhood Development will improve provincial early childhood learning and the K-12 education system to further opportunities for the people of Newfoundland and Labrador.

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Section One: Newfoundland and Labrador Curriculum

Introduction

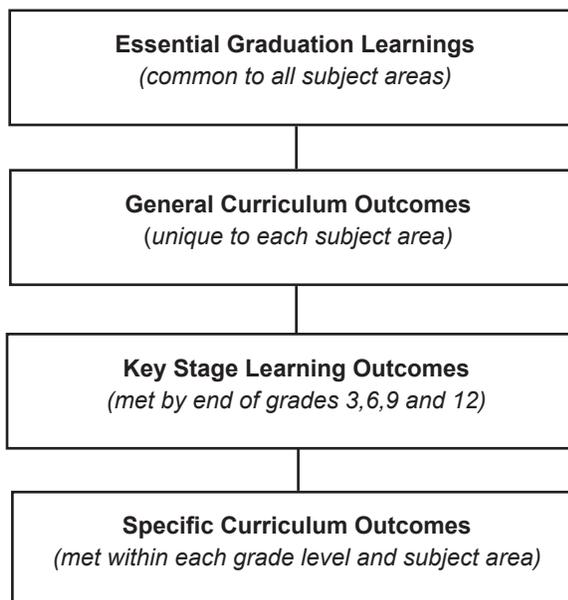
There are multiple factors that impact education: technological developments, increased emphasis on accountability, and globalization. These factors point to the need to consider carefully the education students receive.

The Newfoundland and Labrador Department of Education and Early Childhood Development believes that curriculum design with the following characteristics will help teachers address the needs of students served by the provincially prescribed curriculum:

- Curriculum guides must clearly articulate what students are expected to know and be able to do by the time they graduate from high school.
- There must be purposeful assessment of students' performance in relation to the curriculum outcomes.

Outcomes Based Education

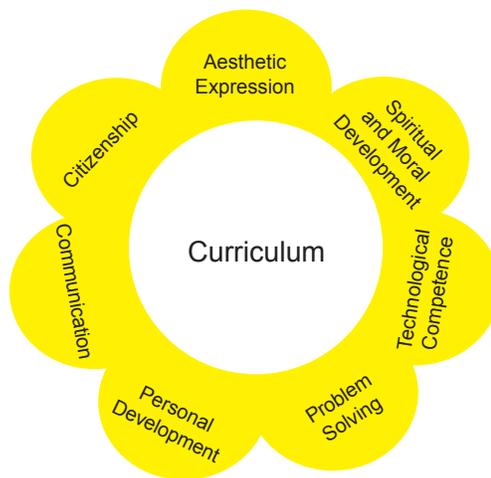
The K-12 curriculum in Newfoundland and Labrador is organized by outcomes and is based on *The Atlantic Canada Framework for Essential Graduation Learning in Schools* (1997). This framework consists of Essential Graduation Learnings (EGLs), General Curriculum Outcomes (GCOs), Key Stage Curriculum Outcomes (KSCOs) and Specific Curriculum Outcomes (SCOs).



Essential Graduation Learnings

EGLs provide vision for the development of a coherent and relevant curriculum. They are statements that offer students clear goals and a powerful rationale for education. The EGLs are delineated by general, key stage, and specific curriculum outcomes.

EGLs describe the knowledge, skills, and attitudes expected of all students who graduate from high school. Achievement of the EGLs will prepare students to continue to learn throughout their lives. EGLs describe expectations, not in terms of individual subject areas, but in terms of knowledge, skills, and attitudes developed throughout the K-12 curriculum. They confirm that students need to make connections and develop abilities across subject areas if they are to be ready to meet the shifting and ongoing demands of life, work, and study.



Aesthetic Expression – Graduates will be able to respond with critical awareness to various forms of the arts and be able to express themselves through the arts.

Citizenship – Graduates will be able to assess social, cultural, economic, and environmental interdependence in a local and global context.

Communication – Graduates will be able to use the listening, viewing, speaking, reading and writing modes of language(s), and mathematical and scientific concepts and symbols, to think, learn and communicate effectively.

Problem Solving – Graduates will be able to use the strategies and processes needed to solve a wide variety of problems, including those requiring language, and mathematical and scientific concepts.

Personal Development – Graduates will be able to continue to learn and to pursue an active, healthy lifestyle.

Spiritual and Moral Development – Graduates will demonstrate understanding and appreciation for the place of belief systems in shaping the development of moral values and ethical conduct.

Technological Competence – Graduates will be able to use a variety of technologies, demonstrate an understanding of technological applications, and apply appropriate technologies for solving problems.

Curriculum Outcomes

Curriculum outcomes are statements that articulate what students are expected to know and be able to do in each program area in terms of knowledge, skills, and attitudes.

Curriculum outcomes may be subdivided into General Curriculum Outcomes, Key Stage Curriculum Outcomes, and Specific Curriculum Outcomes.

General Curriculum Outcomes (GCOs)

Each program has a set of GCOs which describe what knowledge, skills, and attitudes students are expected to demonstrate as a result of their cumulative learning experiences within a subject area. GCOs serve as conceptual organizers or frameworks which guide study within a program area. Often, GCOs are further delineated into KSCOs.

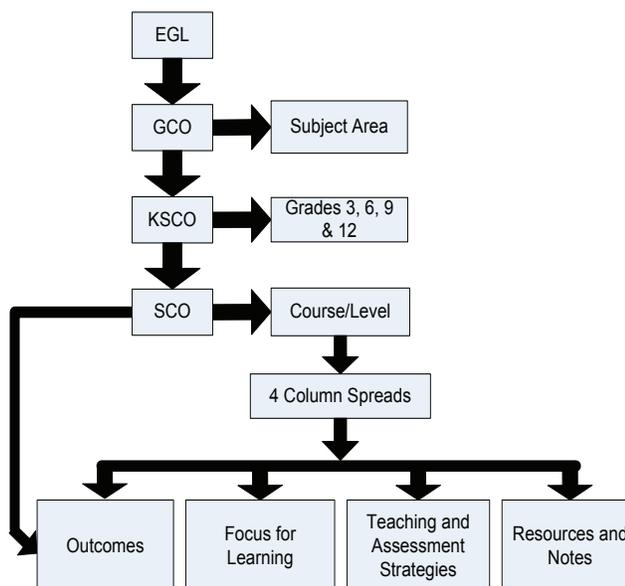
Key Stage Curriculum Outcomes (KSCOs)

Key Stage Curriculum Outcomes (KSCOs) summarize what is expected of students at each of the four key stages of grades three, six, nine, and twelve.

Specific Curriculum Outcomes (SCOs)

SCOs set out what students are expected to know and be able to do as a result of their learning experiences in a course, at a specific grade level. In some program areas, SCOs are further articulated into delineations. *It is expected that all SCOs will be addressed during the course of study covered by the curriculum guide.*

EGLs to Curriculum Guides



Context for Teaching and Learning

Teachers are responsible to help students achieve outcomes. This responsibility is a constant in a changing world. As programs change over time so does educational context. Several factors make up the educational context in Newfoundland and Labrador today: inclusive education, support for gradual release of responsibility teaching model, focus on literacy and learning skills in all programs, and support for education for sustainable development.

Inclusive Education

Valuing Equity and Diversity

Effective inclusive schools have the following characteristics: supportive environment, positive relationships, feelings of competence, and opportunities to participate. (The Centre for Inclusive Education, 2009)

All students need to see their lives and experiences reflected in their school community. It is important that the curriculum reflect the experiences and values of all genders and that learning resources include and reflect the interests, achievements, and perspectives of all students. An inclusive classroom values the varied experiences and abilities as well as social and ethno-cultural backgrounds of all students while creating opportunities for community building. Inclusive policies and practices promote mutual respect, positive interdependencies, and diverse perspectives. Learning resources should include a range of materials that allow students to consider many viewpoints and to celebrate the diverse aspects of the school community.



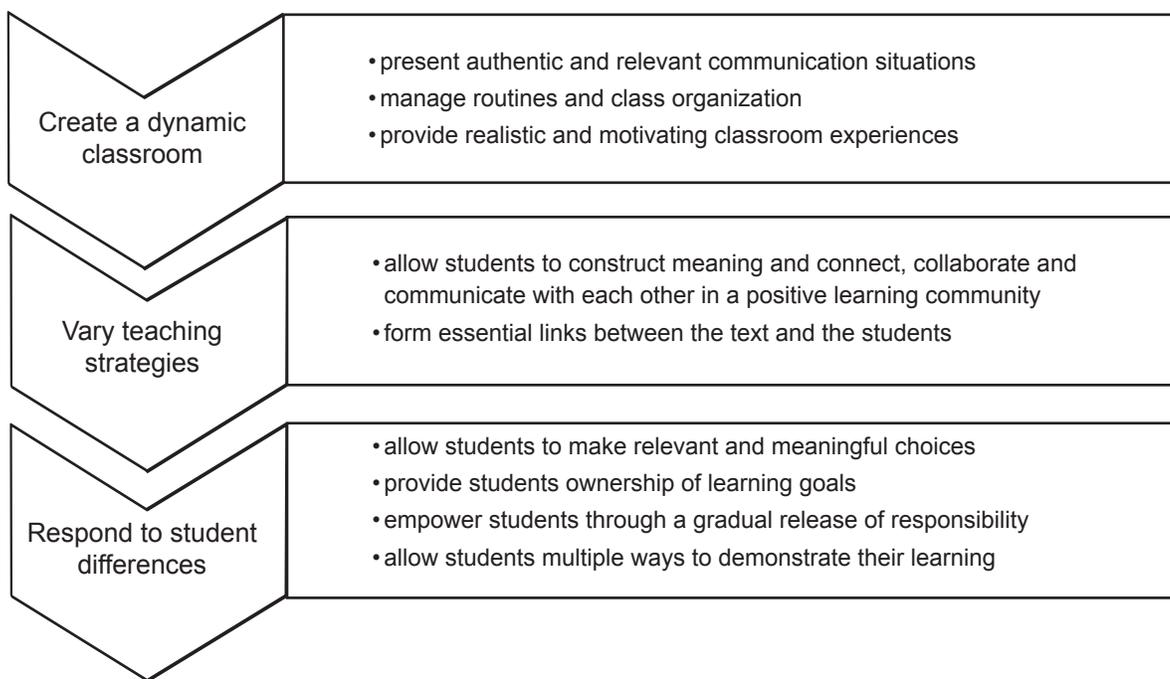
Differentiated Instruction

Differentiated instruction is a teaching philosophy based on the premise that teachers should adapt instruction to student differences. Rather than marching students through the curriculum lockstep, teachers should modify their instruction to meet students' varying readiness levels, learning preferences, and interests. Therefore, the teacher proactively plans a variety of ways to 'get it' and express learning. (Carol Ann Tomlinson, 2008)

Curriculum is designed and implemented to provide learning opportunities for all students according to abilities, needs, and interests. Teachers must be aware of and responsive to the diverse range of learners in their classes. Differentiated instruction is a useful tool in addressing this diversity.

Differentiated instruction responds to different readiness levels, abilities, and learning profiles of students. It involves actively planning so that the process by which content is delivered, the way the resource is used, and the products students create are in response to the teacher's knowledge of whom he or she is interacting with. Learning environments should be flexible to accommodate various learning preferences of the students. Teachers continually make decisions about selecting teaching strategies and structuring learning activities that provide all students with a safe and supportive place to learn and succeed.

Planning for Differentiation



Differentiating the Content

Differentiating content requires teachers to pre-assess students to identify those who require prerequisite instruction, as well as those who have already mastered the concept and may therefore apply strategies learned to new situations. Another way to differentiate content is to permit students to adjust the pace at which they progress through the material. Some students may require additional time while others will move through at an increased pace and thus create opportunities for enrichment or more in-depth consideration of a topic of particular interest.

Teachers should consider the following examples of differentiating content:

- Meet with small groups to reteach an idea or skill or to extend the thinking or skills.
- Present ideas through auditory, visual, and tactile means.
- Use reading materials such as novels, websites, and other reference materials at varying reading levels.

Differentiating the Process

Differentiating the process involves varying learning activities or strategies to provide appropriate methods for students to explore and make sense of concepts. A teacher might assign all students the same product (e.g., presenting to peers) but the process students use to create the presentation may differ. Some students could work in groups while others meet with the teacher individually. The same assessment criteria can be used for all students.

Teachers should consider flexible grouping of students such as whole class, small group, or individual instruction. Students can be grouped according to their learning styles, readiness levels, interest areas, and/or the requirements of the content or activity presented. Groups should be formed for specific purposes and be flexible in composition and short-term in duration.

Teachers should consider the following examples of differentiating the process:

- Offer hands-on activities for students.
- Provide activities and resources that encourage students to further explore a topic of particular interest.
- Use activities in which all learners work with the same learning outcomes but proceed with different levels of support, challenge, or complexity.

Differentiating the Product

Differentiating the product involves varying the complexity and type of product that students create to demonstrate learning outcomes. Teachers provide a variety of opportunities for students to demonstrate and show evidence of what they have learned.

Teachers should give students options to demonstrate their learning (e.g., create an online presentation, write a letter, or develop a mural). This will lead to an increase in student engagement.

Differentiating the Learning Environment

The learning environment includes the physical and the affective tone or atmosphere in which teaching and learning take place, and can include the noise level in the room, whether student activities are static or mobile, or how the room is furnished and arranged. Classrooms may include tables of different shapes and sizes, space for quiet individual work, and areas for collaboration.

Teachers can divide the classroom into sections, create learning centres, or have students work both independently and in groups. The structure should allow students to move from whole group, to small group, pairs, and individual learning experiences and support a variety of ways to engage in learning. Teachers should be sensitive and alert to ways in which the classroom environment supports their ability to interact with students.

Teachers should consider the following examples of differentiating the learning environment:

- Develop routines that allow students to seek help when teachers are with other students and cannot provide immediate attention.
- Ensure there are places in the room for students to work quietly and without distraction, as well as places that invite student collaboration.
- Establish clear guidelines for independent work that match individual needs.
- Provide materials that reflect diversity of student background, interests, and abilities.

The physical learning environment must be structured in such a way that all students can gain access to information and develop confidence and competence.

Meeting the Needs of Students with Exceptionalities

All students have individual learning needs. Some students, however, have exceptionalities (defined by the Department of Education and Early Childhood Development) which impact their learning. The majority of students with exceptionalities access the prescribed curriculum. For details of these exceptionalities see www.gov.nl.ca/edu/k12/studentssupportservices/exceptionalities.html

Supports for these students may include

1. Accommodations
2. Modified Prescribed Courses
3. Alternate Courses
4. Alternate Programs
5. Alternate Curriculum

For further information, see Service Delivery Model for Students with Exceptionalities at www.cdli.ca/sdm/

Classroom teachers should collaborate with instructional resource teachers to select and develop strategies which target specific learning needs.

*Meeting the Needs
of Students who are
Highly Able
(includes gifted and
talented)*

Some students begin a course or topic with a vast amount of prior experience and knowledge. They may know a large portion of the material before it is presented to the class or be capable of processing it at a rate much faster than their classmates. All students are expected to move forward from their starting point. Many elements of differentiated instruction are useful in addressing the needs of students who are highly able.

Teachers may

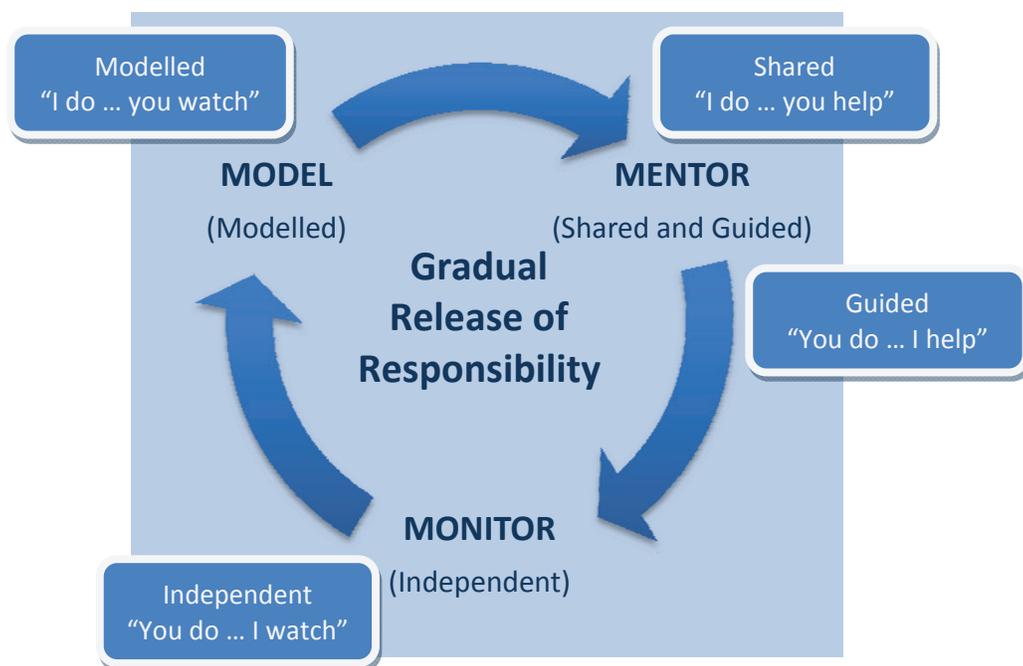
- assign independent study to increase depth of exploration in an area of particular interest;
- compact curriculum to allow for an increased rate of content coverage commensurate with a student's ability or degree of prior knowledge;
- group students with similar abilities to provide the opportunity for students to work with their intellectual peers and elevate discussion and thinking, or delve deeper into a particular topic; and
- tier instruction to pursue a topic to a greater depth or to make connections between various spheres of knowledge.

Highly able students require the opportunity for authentic investigation to become familiar with the tools and practices of the field of study. Authentic audiences and tasks are vital for these learners. Some highly able learners may be identified as gifted and talented in a particular domain. These students may also require supports through the Service Delivery Model for Students with Exceptionalities.

Gradual Release of Responsibility

Teachers must determine when students can work independently and when they require assistance. In an effective learning environment, teachers choose their instructional activities to model and scaffold composition, comprehension, and metacognition that is just beyond the students' independence level. In the gradual release of responsibility approach, students move from a high level of teacher support to independent work. If necessary, the teacher increases the level of support when students need assistance. The goal is to empower students with their own learning strategies, and to know how, when, and why to apply them to support their individual growth. Guided practice supports student independence. As a student demonstrates success, the teacher should gradually decrease his or her support.

Gradual Release of Responsibility Model



Literacy

“Literacy is the ability to identify, understand, interpret, create, communicate and compute, using printed and written materials associated with varying contexts. Literacy involves a continuum of learning in enabling individuals to achieve their goals, to develop their knowledge and potential, and to participate fully in their community and wider society”. To be successful, students require a set of interrelated skills, strategies and knowledge in multiple literacies that facilitate their ability to participate fully in a variety of roles and contexts in their lives, in order to explore and interpret the world and communicate meaning. (The Plurality of Literacy and its Implications for Policies and Programmes, 2004, p.13)

Literacy is

- a process of receiving information and making meaning from it; and
- the ability to identify, understand, interpret, communicate, compute, and create text, images, and sounds.

Literacy development is a lifelong learning enterprise beginning at birth that involves many complex concepts and understandings. It is not limited to the ability to read and write; no longer are we exposed only to printed text. It includes the capacity to learn to communicate, read, write, think, explore, and solve problems. Individuals use literacy skills in paper, digital, and live interactions to engage in a variety of activities:

- Analyze critically and solve problems.
- Comprehend and communicate meaning.
- Create a variety of texts.
- Make connections both personally and inter-textually.
- Participate in the socio-cultural world of the community.
- Read and view for enjoyment.
- Respond personally.

These expectations are identified in curriculum documents for specific subject areas as well as in supporting documents, such as *Cross-Curricular Reading Tools (CAMET)*.

With modelling, support, and practice, students' thinking and understandings are deepened as they work with engaging content and participate in focused conversations.

Reading in the Content Areas

The focus for reading in the content areas is on teaching strategies for understanding content. Teaching strategies for reading comprehension benefits all students as they develop transferable skills that apply across curriculum areas.

When interacting with different texts, students must read words, view and interpret text features, and navigate through information presented in a variety of ways including, but not limited to

Advertisements	Movies	Poems
Blogs	Music videos	Songs
Books	Online databases	Speeches
Documentaries	Plays	Video games
Magazine articles	Podcasts	Websites

Students should be able to interact with and comprehend different texts at different levels.

There are three levels of text comprehension:

- Independent level – Students are able to read, view, and understand texts without assistance.
- Instructional level – Students are able to read, view, and understand most texts but need assistance to fully comprehend some texts.
- Frustration level – Students are not able to read or view with understanding (i.e., texts may be beyond their current reading level).

Teachers will encounter students working at all reading levels in their classrooms and will need to differentiate instruction to meet their needs. For example, print texts may be presented in audio form, physical movement may be associated with synthesizing new information with prior knowledge, or graphic organizers may be created to present large amounts of print text in a visual manner.

When interacting with information that is unfamiliar to students, it is important for teachers to monitor how effectively students are using strategies to read and view texts:

- Analyze and think critically about information.
- Determine importance to prioritize information.
- Engage in questioning before, during, and after an activity related to a task, text, or problem.
- Make inferences about what is meant but not said.
- Make predictions.
- Synthesize information to create new meaning.
- Visualize ideas and concepts.

Learning Skills for Generation Next

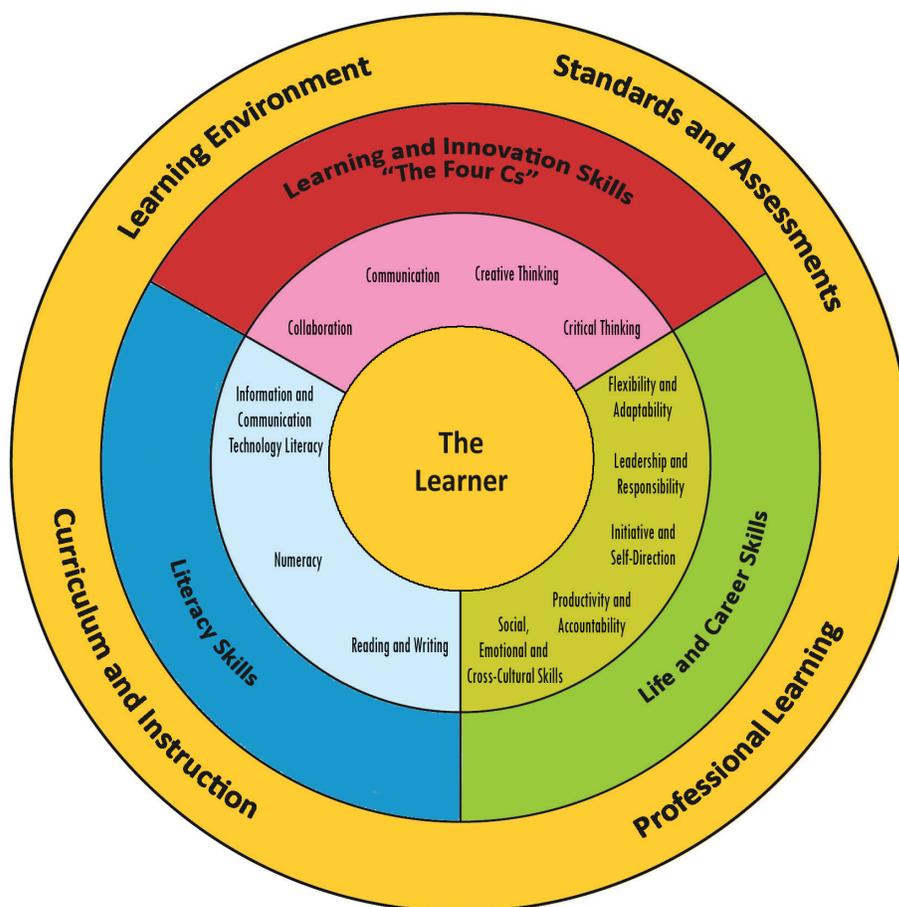
Generation Next is the group of students who have not known a world without personal computers, cell phones, and the Internet. They were born into this technology. They are digital natives.

Students need content and skills to be successful. Education helps students learn content and develop skills needed to be successful in school and in all learning contexts and situations. Effective learning environments and curricula challenge learners to develop and apply key skills within the content areas and across interdisciplinary themes.

Learning Skills for Generation Next encompasses three broad areas:

- Learning and Innovation Skills enhance a person's ability to learn, create new ideas, problem solve, and collaborate.
- Life and Career Skills address leadership, and interpersonal and affective domains.
- Literacy Skills develop reading, writing, and numeracy, and enhance the use of information and communication technology.

The diagram below illustrates the relationship between these areas. A 21st century curriculum employs methods that integrate innovative and research-driven teaching strategies, modern learning technologies, and relevant resources and contexts.



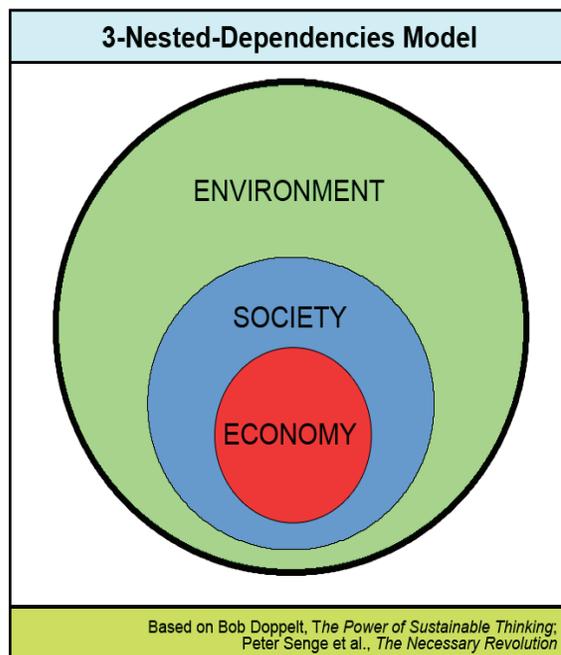
Support for students to develop these abilities and skills is important across curriculum areas and should be integrated into teaching, learning, and assessment strategies. Opportunities for integration of these skills and abilities should be planned with engaging and experiential activities that support the gradual release of responsibility model. For example, lessons in a variety of content areas can be infused with learning skills for Generation Next by using open-ended questioning, role plays, inquiry approaches, self-directed learning, student role rotation, and Internet-based technologies.

All programs have a shared responsibility in developing students' capabilities within all three skill areas.

Education for Sustainable Development

Sustainable development is defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. (Our Common Future, 43)

Sustainable development is comprised of three integrally connected areas: economy, society, and environment.



As conceived by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) the overall goal of Education for Sustainable Development (ESD) is to integrate the knowledge, skills, values, and perspectives of sustainable development into all aspects of education and learning. Changes in human behaviour should create a more sustainable future that supports environmental integrity and economic viability, resulting in a just society for all generations.

ESD involves teaching *for* rather than teaching *about* sustainable development. In this way students develop the skills, attitudes, and perspectives to meet their present needs without compromising the ability of future generations to meet their needs.

Within ESD, the knowledge component spans an understanding of the interconnectedness of our political, economic, environmental, and social worlds, to the role of science and technology in the development of societies and their impact on the environment. The skills necessary include being able to assess bias, analyze consequences of choices, ask questions, and solve problems. ESD values and perspectives include an appreciation for the interdependence of all life forms, the importance of individual responsibility and action, an understanding of global issues as well as local issues in a global context. Students need to be aware that every issue has a history, and that many global issues are linked.

Assessment and Evaluation

Assessment

Assessment is the process of gathering information on student learning.

How learning is assessed and evaluated and how results are communicated send clear messages to students and others about what is valued.

Assessment instruments are used to gather information for evaluation. Information gathered through assessment helps teachers determine students' strengths and needs, and guides future instruction.

Teachers are encouraged to be flexible in assessing student learning and to seek diverse ways students might demonstrate what they know and are able to do.

Evaluation involves the weighing of the assessment information against a standard in order to make a judgement about student achievement.

Assessment can be used for different purposes:

1. Assessment *for* learning guides and informs instruction.
2. Assessment *as* learning focuses on what students are doing well, what they are struggling with, where the areas of challenge are, and what to do next.
3. Assessment *of* learning makes judgements about student performance in relation to curriculum outcomes.

1. Assessment for Learning

Assessment *for* learning involves frequent, interactive assessments designed to make student learning visible. This enables teachers to identify learning needs and adjust teaching accordingly.

Assessment *for* learning is not about a score or mark; it is an ongoing process of teaching and learning:

- Pre-assessments provide teachers with information about what students already know and can do.
- Self-assessments allow students to set goals for their own learning.
- Assessment *for* learning provides descriptive and specific feedback to students and parents regarding the next stage of learning.
- Data collected during the learning process from a range of tools enables teachers to learn as much as possible about what a student knows and is able to do.

2. *Assessment as Learning*

Assessment as learning involves students' reflecting on their learning and monitoring their own progress. It focuses on the role of the student in developing metacognition and enhances engagement in their own learning. Students can

- analyze their learning in relation to learning outcomes,
- assess themselves and understand how to improve performance,
- consider how they can continue to improve their learning, and
- use information gathered to make adaptations to their learning processes and to develop new understandings.

3. *Assessment of Learning*

Assessment of learning involves strategies designed to confirm what students know in terms of curriculum outcomes. It also assists teachers in determining student proficiency and future learning needs. *Assessment of learning* occurs at the end of a learning experience and contributes directly to reported results. Traditionally, teachers relied on this type of assessment to make judgements about student performance by measuring learning after the fact and then reporting it to others. Used in conjunction with the other assessment processes previously outlined, *assessment of learning* is strengthened. Teachers can

- confirm what students know and can do;
- report evidence to parents/guardians, and other stakeholders, of student achievement in relation to learning outcomes; and
- report on student learning accurately and fairly using evidence obtained from a variety of contexts and sources.

Involving Students in the Assessment Process

Students should know what they are expected to learn as outlined in the specific curriculum outcomes of a course as well as the criteria that will be used to determine the quality of their achievement. This information allows students to make informed choices about the most effective ways to demonstrate what they know and are able to do.

It is important that students participate actively in assessment by co-creating criteria and standards which can be used to make judgements about their own learning. Students may benefit from examining various scoring criteria, rubrics, and student exemplars.

Students are more likely to perceive learning as its own reward when they have opportunities to assess their own progress. Rather than asking teachers, "What do you want?", students should be asking themselves questions:

- What have I learned?
- What can I do now that I couldn't do before?
- What do I need to learn next?

Assessment must provide opportunities for students to reflect on their own progress, evaluate their learning, and set goals for future learning.

Assessment Tools

In planning assessment, teachers should use a broad range of tools to give students multiple opportunities to demonstrate their knowledge, skills, and attitudes. The different levels of achievement or performance may be expressed as written or oral comments, ratings, categorizations, letters, numbers, or as some combination of these forms.

The grade level and the activity being assessed will inform the types of assessment tools teachers will choose:

Anecdotal Records	Photographic Documentation
Audio/Video Clips	Podcasts
Case Studies	Portfolios
Checklists	Presentations
Conferences	Projects
Debates	Questions
Demonstrations	Quizzes
Exemplars	Role Plays
Graphic Organizers	Rubrics
Journals	Self-assessments
Literacy Profiles	Tests
Observations	Wikis

Assessment Guidelines

Assessments should measure what they intend to measure. It is important that students know the purpose, type, and potential marking scheme of an assessment. The following guidelines should be considered:

- Collect evidence of student learning through a variety of methods; do not rely solely on tests and paper and pencil activities.
- Develop a rationale for using a particular assessment of learning at a specific point in time.
- Provide descriptive and individualized feedback to students.
- Provide students with the opportunity to demonstrate the extent and depth of their learning.
- Set clear targets for student success using learning outcomes and assessment criteria.
- Share assessment criteria with students so that they know the expectations.

Evaluation

Evaluation is the process of analyzing, reflecting upon, and summarizing assessment information, and making judgements or decisions based on the information gathered. Evaluation is conducted within the context of the outcomes, which should be clearly understood by learners before teaching and evaluation take place. Students must understand the basis on which they will be evaluated and what teachers expect of them.

During evaluation, the teacher interprets the assessment information, makes judgements about student progress, and makes decisions about student learning programs.

Section Two: Curriculum Design

Rationale

The vision of science education in Newfoundland and Labrador is to develop scientific literacy.

Scientific literacy is an evolving combination of the science-related attitudes, skills, and knowledge students need to develop inquiry, problem solving, and decision making abilities; to become lifelong learners; and to maintain a sense of wonder about the world around them.

To develop scientific literacy, students require diverse learning experiences which provide opportunity to explore, analyze, evaluate, synthesize, appreciate, and understand the interrelationships among science, technology, society, and the environment that will affect their personal lives, careers, and futures.

Science education which strives for scientific literacy must engage students in science inquiry, problem solving, and decision making.

Science Inquiry

Science inquiry involves posing questions and developing explanations for phenomena. While there is general agreement that there is no such thing as the scientific method, students require certain skills to participate in the activities of science. Skills such as questioning, observing, inferring, predicting, measuring, hypothesizing, classifying, designing experiments, collecting data, analyzing data, and interpreting data are fundamental to engaging in science. These skills are often represented as a cycle which involves the posing of questions, the generation of possible explanations, and the collection of evidence to determine which of these explanations is most useful in accounting for the phenomenon under investigation. Teachers should engage students in science inquiry activities to develop these skills.

Problem Solving

Problem solving involves seeking solutions to human problems. It may be represented as a cycle consisting of the proposing, creating, and testing of prototypes, products, and techniques in an attempt to reach an optimum solution to a given problem. The skills involved in this cycle facilitate a process which has different aims and procedures from science inquiry. Students should be given opportunities to propose, perform, and evaluate solutions to problem solving or technological tasks.

Decision Making

Decision making involves determining what we should do in a particular context or in response to a given situation. Increasingly, the types of problems that we deal with, both individually and collectively, require an understanding of the processes and products of science and technology. The process of decision making involves identification of the problem or situation, generation of possible solutions or courses of action, evaluation of the alternatives, and a thoughtful decision based on the information available. Students should be actively involved in decision making situations. While important in their own right, decision making situations also provide a relevant context for engaging in science inquiry and/or problem solving.

Curriculum Outcomes Framework

The basis of the curriculum outcomes framework are the general curriculum outcomes (GCOs). Four general curriculum outcomes have been identified to delineate the four critical aspects of students' scientific literacy: science, technology, society, and the environment (STSE); skills; knowledge; and attitudes. These four GCOs are common to all science courses.

General Curriculum Outcomes

GCO 1: Science, Technology, Society, and the Environment

Students will develop an understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology.

GCO 2: Skills

Students will develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions.

GCO 3: Knowledge

Students will construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge.

GCO 4: Attitudes

Students will be encouraged to develop attitudes that support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society, and the environment.

Key Stage Curriculum Outcomes

Key stage curriculum outcomes (KSCOs) align with the GCOs and summarize what students are expected to know and be able to do by the end of Grade 12.

GCO 1: STSE

By the end of Grade 12, students will be expected to

- describe and explain disciplinary and interdisciplinary processes used to enable us to understand natural phenomena and develop technological solutions
- distinguish between science and technology in terms of their respective goals, products, and values, and describe the development of scientific theories and technologies over time
- analyze and explain how science and technology interact with and advance one another
- analyze how individuals, society, and the environment are interdependent with scientific and technological endeavours
- evaluate social issues related to the applications and limitations of science and technology, and explain decisions in terms of advantages and disadvantages for sustainability, considering a variety of perspectives

GCO 2: Skills

By the end of Grade 12, students will be expected to

- ask questions about observed relationships and plan investigations of questions, ideas, problems, and issues
- conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information
- analyze data and apply mathematical and conceptual models to develop and assess possible explanations
- work as a member of a team in addressing problems, and apply the skills and conventions of science in communicating information and ideas and in assessing results

GCO 3: Knowledge

By the end of Grade 12, students will be expected to

- identify and explain the diversity of organic compounds and their impact on the environment
- demonstrate an understanding of the characteristics and interactions of acids and bases
- illustrate and explain the various forces that hold structures together at the molecular level, and relate the properties of matter to its structure
- use the redox theory in a variety of contexts related to electrochemistry
- demonstrate an understanding of solutions and stoichiometry
- predict and explain energy transfers in chemical reactions

GCO 4: Attitudes

By the end of Grade 12, students will be expected to

- value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not
- appreciate that the applications of science and technology can raise ethical dilemmas
- value the contributions to scientific and technological development made by people from many societies and cultural backgrounds
- show a continuing and more informed curiosity and interest in science and science-related issues
- acquire, with interest and confidence, additional science knowledge and skills, using a variety of resources and methods, including formal research
- consider further studies and careers in science- and technology-related fields
- confidently evaluate evidence and consider alternative perspectives, ideas, and explanations
- use factual information and rational explanations when analyzing and evaluating
- value the processes for drawing conclusions
- work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas
- have a sense of personal and shared responsibility for maintaining a sustainable environment
- project the personal, social, and environmental consequences of proposed action
- want to take action for maintaining a sustainable environment
- show concern for safety and accept the need for rules and regulations
- be aware of the direct and indirect consequences of their actions

Specific Curriculum Outcomes

Specific curriculum outcomes (SCOs) align with the KSCOs and describe what students should know and be able to do at the end of each course. They are intended to serve as the focus for the design of learning experiences and assessment tasks. SCOs are organized into units for each course.

Course Overview

The vision of scientific literacy sets out the need for students to acquire science-related skills, knowledge, and attitudes, and emphasizes that this is best done through the study and analysis of the interrelationships among science, technology, society, and the environment.

Chemistry 2202 SCOs are organized into four units:

- Unit i: Integrated Skills
- Unit 1: Stoichiometry
- Unit 2: From Structures to Properties
- Unit 3: Organic Chemistry

Suggested Yearly Plan

September	October	November	December	January	February	March	April	May	June
Unit 1: Stoichiometry				Unit 2: From Structures to Properties			Unit 3: Organic Chemistry		
Skills Integrated Throughout									

How to Use the Four Column Curriculum Layout

Outcomes

Column one contains specific curriculum outcomes (SCO) and accompanying delineations where appropriate. The delineations provide specificity in relation to key ideas.

Outcomes are numbered in ascending order.

Delineations are indented and numbered as a subset of the originating SCO.

All outcomes are related to general curriculum outcomes.

Focus for Learning

Column two is intended to assist teachers with instructional planning. It also provides context and elaboration of the ideas identified in the first column.

This may include:

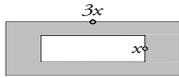
- cautionary notes
- clarity in terms of scope
- common misconceptions
- depth of treatment
- knowledge required to scaffold and challenge student learning
- references to prior knowledge

Sample Performance Indicator(s)

This provides a summative, higher order activity, where the response would serve as a data source to help teachers assess the degree to which the student has achieved the outcome.

Performance indicators are typically presented as a task, which may include an introduction to establish a context. They would be assigned at the end of the teaching period allocated for the outcome.

Performance indicators would be assigned when students have attained a level of competence, with suggestions for teaching and assessment identified in column three.

SPECIFIC CURRICULUM OUTCOMES	
<i>GCO 1: Represent algebraic expressions in multiple ways</i>	
<p>Outcomes</p> <p><i>Students will be expected to</i></p> <p>1.0 model, record and explain the operations of multiplication and division of polynomial expressions (limited to polynomials of degree less than or equal to 2) by monomials, concretely, pictorially and symbolically. [GCO 1]</p> <p>1.2 model division of a given polynomial expression by a given monomial concretely or pictorially and record the process symbolically.</p> <p>1.3 apply a personal strategy for multiplication and division of a given polynomial expression</p>	<p>Focus for Learning</p> <p>From previous work with number operations, students should be aware that division is the inverse of multiplication. This can be extended to divide polynomials by monomials. The study of division should begin with division of a monomial by a monomial, progress to a polynomial by a scalar, and then to division of a polynomial by any monomial.</p> <p>Division of a polynomial by a monomial can be visualized using area models with algebra tiles. The most commonly used symbolic method of dividing a polynomial by a monomial at this level is to divide each term of the polynomial by the monomial, and then use the exponent laws to simplify. This method can also be easily modelled using tiles, where students use the sharing model for division.</p> <p>Because there are a variety of methods available to multiply or divide a polynomial by a monomial, students should be given the opportunity to apply their own personal strategies. They should be encouraged to use algebra tiles, area models, rules of exponents, the distributive property and repeated addition, or a combination of any of these methods, to multiply or divide polynomials. Regardless of the method used, students should be encouraged to record their work symbolically. Understanding the different approaches helps students develop flexible thinking.</p> <p>Sample Performance Indicator</p> <p>Write an expression for the missing dimensions of each rectangle and determine the area of the walkway in the following problem:</p> <ul style="list-style-type: none"> • The inside rectangle in the diagram below is a flower garden. The shaded area is a concrete walkway around it. The area of the flower garden is given by the expression $2x^2 + 4x$ and the area of the large rectangle, including the walkway and the flower garden, is $3x^2 + 6x$. 

SPECIFIC CURRICULUM OUTCOMES

*GCO 1: Represent algebraic expressions in multiple ways***Sample Teaching and Assessment Strategies**

Teachers may use the following activities and/or strategies aligned with the corresponding assessment tasks:

Modeling division using the sharing model provides a good transition to the symbolic representation. For example, $\frac{3x+12}{3} = \frac{3x}{3} + \frac{12}{3}$. To model this, students start with a collection of three x -tiles and 12 unit tiles and divide them into three groups.



For this example, $x + 4$ tiles will be a part of each group, so the quotient is $x + 4$.

Activation

Students may

- Model division of a polynomial by a monomial by creating a rectangle using four x^2 -tiles and eight x -tiles, where $4x$ is one of the dimensions.

Teachers may

- Ask students what the other dimension is and connect this to the symbolic representation.

Connection

Students may

- Model division of polynomials and determine the quotient
 - (i) $(6x^2 + 12x - 3) \div 3$
 - (ii) $(4x^2 - 12x) \div 4x$

Consolidation

Students may

- Draw a rectangle with an area of $36a^2 + 12a$ and determine as many different dimensions as possible.

Teachers may

- Discuss why there are so many different possible dimensions.

Extension

Students may

- Determine the area of one face of a cube whose surface area is represented by the polynomial $24s^2$.
- Determine the length of an edge of the cube.

Resources and Notes**Authorized**

- *Math Makes Sense 9*
- Lesson 5.5: Multiplying and Dividing a Polynomial by a Constant
- Lesson 5.6: Multiplying and Dividing a Polynomial by a Monomial
- ProGuide: pp. 35-42, 43-51
- CD-ROM: Master 5.23, 5.24
- See It Videos and Animations:
 - Multiplying and Dividing a Polynomial by a Constant, Dividing
 - Multiplying and Dividing a Polynomial by a Monomial, Dividing
- SB: pp. 241-248, 249-257
- PB: pp. 206-213, 214-219

Resources and Notes

Column four references supplementary information and possible resources for use by teachers.

These references will provide details of resources suggested in column two and column three.

Suggestions for Teaching and Assessment

This column contains specific sample tasks, activities, and strategies that enable students to meet the goals of the SCOs and be successful with performance indicators. Instructional activities are recognized as possible sources of data for assessment purposes. Frequently, appropriate techniques and instruments for assessment purposes are recommended.

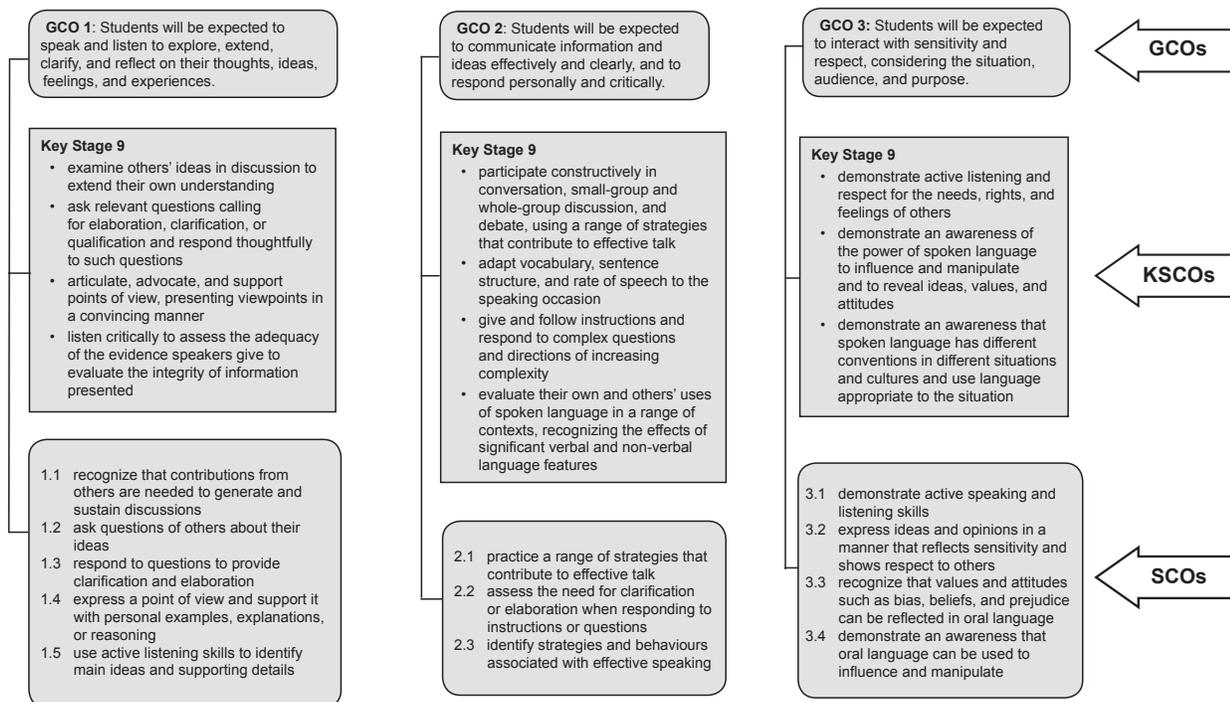
Suggestions for instruction and assessment are organized sequentially:

- **Activation** – suggestions that may be used to activate prior learning and establish a context for the instruction
- **Connection** – linking new information and experiences to existing knowledge inside or outside the curriculum area
- **Consolidation** – synthesizing and making new understandings
- **Extension** – suggestions that go beyond the scope of the outcome

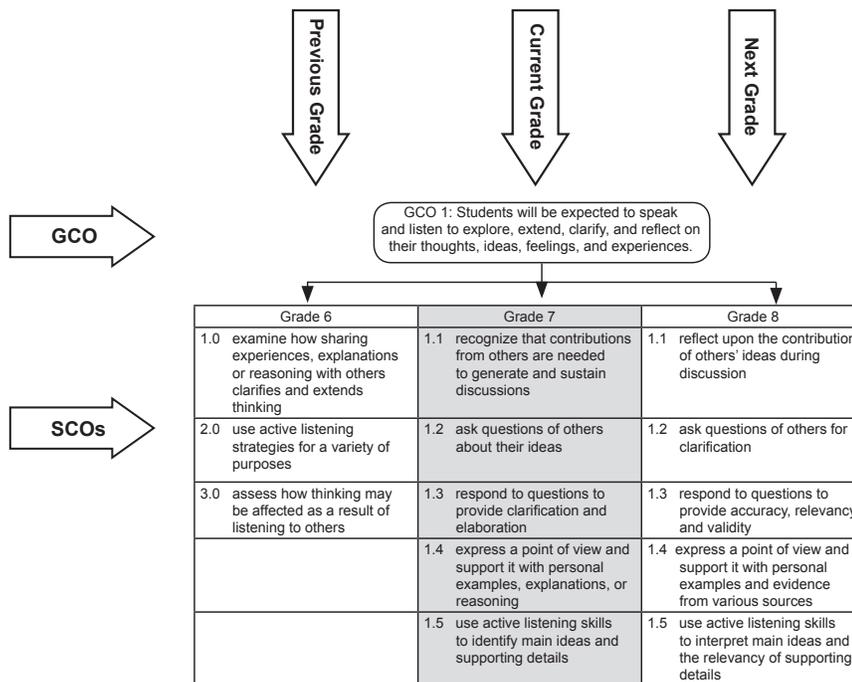
These suggestions provide opportunities for differentiated learning and assessment.

How to use a Strand overview

At the beginning of each strand grouping there is explanation of the focus for the strand and a flow chart identifying the relevant GCOs, KSCOs, and SCOs.



The SCOs Continuum follows the chart to provide context for teaching and assessment for the grade/course in question. The current grade is highlighted in the chart.



Section Three:
Specific Curriculum Outcomes

Unit i: Integrated Skills

Strand Overview

Focus

Students use a variety of skills in the process of answering questions, solving problems, and making decisions. While these skills are not unique to science, they play an important role in the development of scientific understandings and in the application of science and technology to new situations.

The listing of skills is not intended to imply a linear sequence or to identify a single set of skills required in each science investigation. Every investigation and application of science has unique features that determine the particular mix and sequence of skills involved.

Four broad areas of skills are outlined and developed:

- Initiating and Planning –These are the skills of questioning, identifying problems, and developing initial ideas and plans.
- Performing and Recording –These are the skills of carrying out action plans, which involves gathering evidence by observation and, in most cases, manipulating materials and equipment.
- Analyzing and Interpreting –These are the skills of examining information and evidence, of processing and presenting data so that it can be interpreted, and interpreting, evaluating, and applying the results.
- Communication and Teamwork – In science, as in other areas, communication skills are essential at every stage where ideas are being developed, tested, interpreted, debated, and agreed upon. Teamwork skills are also important, since the development and application of science ideas is a collaborative process both in society and in the classroom.

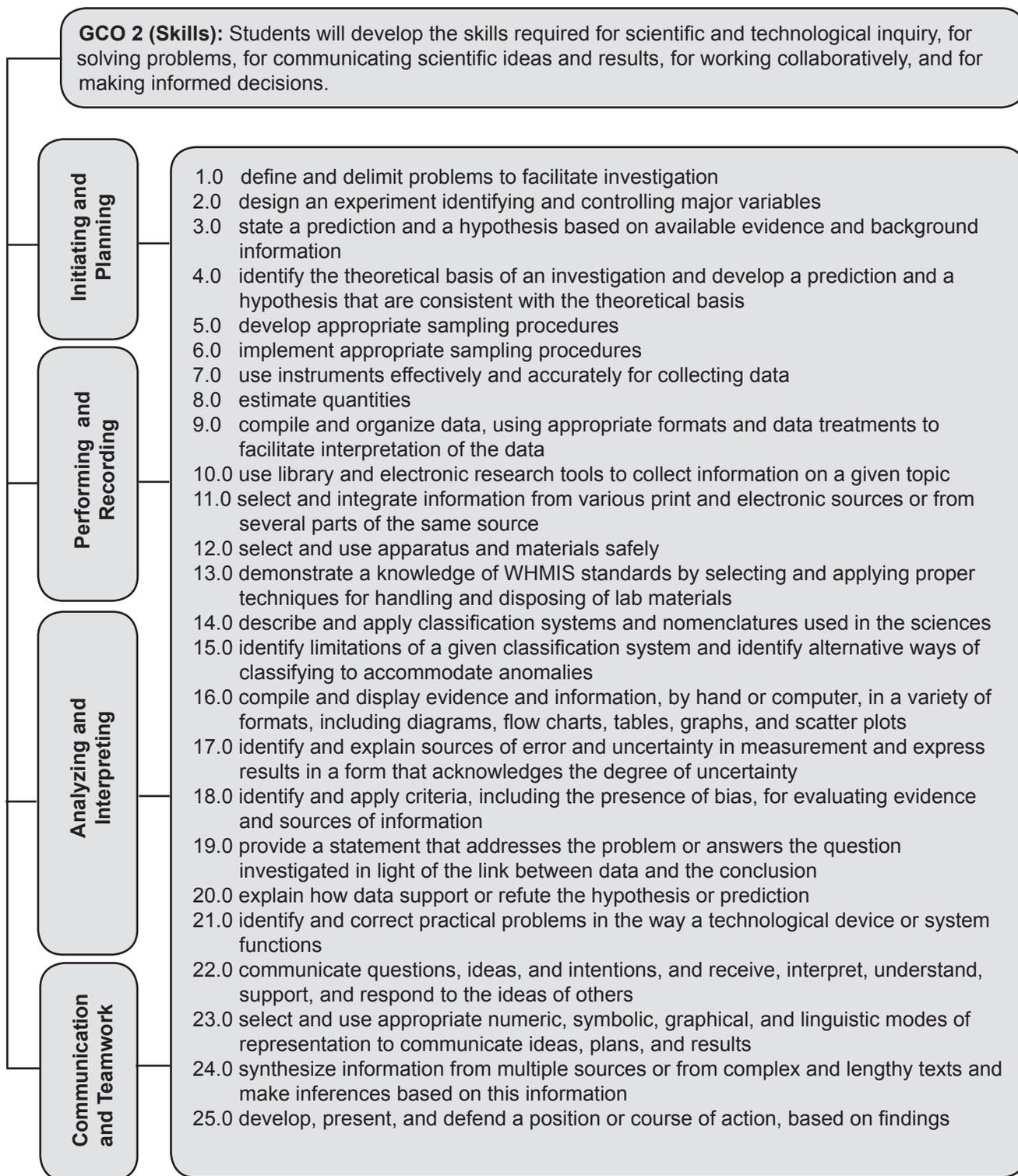
Students should be provided with opportunities to develop and apply their skills in a variety of contexts. These contexts connect to the STSE component of the curriculum by linking to three processes for skills application:

- Science inquiry – seeking answers to questions through experimentation and research
- Problem solving – seeking solutions to science-related problems by developing and testing prototypes, products, and techniques to meet a given need.
- Decision making – providing information to assist the decision making process.

Unit i: Integrated Skills

Unit i, The Integrated Skills Unit, appears at the beginning of this curriculum guide. A total of forty-three skills are addressed throughout science courses in grades 10-12; however, not all skills appear in every curriculum guide or course. In Chemistry 2202, there is a focus on twenty-five skills; these are listed on the following page.

Outcomes Framework



SCO Skills Continuum

GCO 2 (Skills): Students will develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions.

Science 7-9	Science 10-12
<ul style="list-style-type: none"> rephrase questions in a testable form and clearly define practical problems identify questions to investigate arising from practical problems and issues 	<ul style="list-style-type: none"> identify questions to investigate that arise from practical problems and issues
<ul style="list-style-type: none"> define and delimit questions and problems to facilitate investigation 	<ul style="list-style-type: none"> define and delimit problems to facilitate investigation
<ul style="list-style-type: none"> design an experiment and identify major variables 	<ul style="list-style-type: none"> design an experiment identifying and controlling major variables design an experiment and identify specific variables
<ul style="list-style-type: none"> state a prediction and a hypothesis based on background information or an observed pattern of events 	<ul style="list-style-type: none"> state a prediction and a hypothesis based on available evidence and background information identify the theoretical basis of an investigation and develop a prediction and a hypothesis that are consistent with the theoretical basis
<ul style="list-style-type: none"> formulate operational definitions of major variables and other aspects of their investigations 	<ul style="list-style-type: none"> formulate operational definitions of major variables
<ul style="list-style-type: none"> select appropriate methods and tools for collecting data and information and for solving problems 	<ul style="list-style-type: none"> evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making develop appropriate sampling procedures
	<ul style="list-style-type: none"> implement appropriate sampling procedures
<ul style="list-style-type: none"> carry out procedures controlling the major variables 	<ul style="list-style-type: none"> carry out procedures controlling the major variables and adapting or extending procedures where required
<ul style="list-style-type: none"> use instruments effectively and accurately for collecting data 	<ul style="list-style-type: none"> use instruments effectively and accurately for collecting data
<ul style="list-style-type: none"> estimate quantities 	<ul style="list-style-type: none"> estimate quantities
<ul style="list-style-type: none"> organize data using a format that is appropriate to the task or experiment 	<ul style="list-style-type: none"> compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data
<ul style="list-style-type: none"> select and integrate information from various print and electronic sources or from several parts of the same source 	<ul style="list-style-type: none"> use library and electronic research tools to collect information on a given topic select and integrate information from various print and electronic sources or from several parts of the same source
<ul style="list-style-type: none"> use tools and apparatus safely 	<ul style="list-style-type: none"> select and use apparatus and materials safely
<ul style="list-style-type: none"> demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials 	<ul style="list-style-type: none"> demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials

SCO Skills Continuum

Science 7-9	Science 10-12
<ul style="list-style-type: none"> use or construct a classification key 	<ul style="list-style-type: none"> describe and apply classification systems and nomenclatures used in the sciences identify limitations of a given classification system and identify alternative ways of classifying to accommodate anomalies
<ul style="list-style-type: none"> compile and display data, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, bar graphs, line graphs, and scatter plots 	<ul style="list-style-type: none"> compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots
<ul style="list-style-type: none"> identify strengths and weaknesses of different methods of collecting and displaying data 	
<ul style="list-style-type: none"> predict the value of a variable by interpolating or extrapolating from graphical data 	
<ul style="list-style-type: none"> identify a line of best fit on a scatter plot and interpolate or extrapolate based on the line of best fit 	<ul style="list-style-type: none"> identify a line of best fit on a scatter plot and interpolate or extrapolate based on the line of best fit
<ul style="list-style-type: none"> interpret patterns and trends in data, and infer and explain relationships among the variables 	<ul style="list-style-type: none"> interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables
	<ul style="list-style-type: none"> apply and assess alternative theoretical models for interpreting knowledge in a given field
<ul style="list-style-type: none"> identify, and suggest explanations for discrepancies in data 	
<ul style="list-style-type: none"> apply given criteria for evaluating evidence and sources of information 	
<ul style="list-style-type: none"> calculate theoretical values of a variable 	<ul style="list-style-type: none"> compare theoretical and empirical values and account for discrepancies
	<ul style="list-style-type: none"> evaluate the relevance, reliability, and adequacy of data and data collection methods
	<ul style="list-style-type: none"> identify and apply criteria, including the presence of bias, for evaluating evidence and sources of information
<ul style="list-style-type: none"> identify potential sources of and determine the amount of error in measurement 	<ul style="list-style-type: none"> identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty
<ul style="list-style-type: none"> state a conclusion, based on experimental data, and explain how evidence gathered supports or refutes an initial idea 	<ul style="list-style-type: none"> provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion explain how data support or refute the hypothesis or prediction
<ul style="list-style-type: none"> identify and correct practical problems in the way a prototype or constructed device functions 	<ul style="list-style-type: none"> identify and correct practical problems in the way a technological device or system functions

SCO Skills Continuum

Science 7-9	Science 10-12
<ul style="list-style-type: none"> test the design of a constructed device or system 	<ul style="list-style-type: none"> construct and test a prototype of a device or system and troubleshoot problems as they arise
	<ul style="list-style-type: none"> propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each, and select one as the basis for a plan
<ul style="list-style-type: none"> evaluate designs and prototypes in terms of function, reliability, safety, efficiency, use of materials, and impact on the environment 	<ul style="list-style-type: none"> evaluate a personally designed and constructed device on the basis of criteria they have developed themselves
<ul style="list-style-type: none"> identify new questions and problems that arise from what was learned 	<ul style="list-style-type: none"> identify new questions or problems that arise from what was learned
<ul style="list-style-type: none"> identify and evaluate potential applications of findings 	<ul style="list-style-type: none"> identify and evaluate potential applications of findings
<ul style="list-style-type: none"> receive, understand, and act on the ideas of others communicate questions, ideas, intentions, plans, and results, using lists, notes in point form, sentences, data tables, graphs, drawings, oral language, and other means 	<ul style="list-style-type: none"> communicate questions, ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results
	<ul style="list-style-type: none"> synthesize information from multiple sources or from complex and lengthy texts and make inferences based on this information
	<ul style="list-style-type: none"> identify multiple perspectives that influence a science-related decision or issue
<ul style="list-style-type: none"> defend a given position on an issue or problem, based on their findings 	<ul style="list-style-type: none"> develop, present, and defend a position or course of action, based on findings
<ul style="list-style-type: none"> work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise 	<ul style="list-style-type: none"> work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise
<ul style="list-style-type: none"> evaluate individual and group processes used in planning, problem solving, decision-making, and completing a task 	<ul style="list-style-type: none"> evaluate individual and group processes used in planning, problem solving, decision-making, and completing a task

Suggested Unit Plan

The Integrated Skills unit is not intended to be taught as a stand alone unit. Rather, when skill outcomes [GCO 2] are encountered in units 1-3, teachers should refer out to the focus for learning elaborations and teaching and assessment suggestions provided here.

Skill outcomes have been integrated within units 1-3. Students should be provided with opportunities to develop and apply these skills in varied contexts:

- Science Inquiry – seeking answers to questions through experimentation and research
- Problem Solving – seeking solutions to science-related problems by developing and testing prototypes, products, and techniques to meet a given need
- Decision Making – providing information to assist the decision making process

September	October	November	December	January	February	March	April	May	June
Unit 1: Stoichiometry				Unit 2: From Structures to Properties			Unit 3: Organic Chemistry		
Skills Integrated Throughout									

Initiating and Planning

Outcomes

Students will be expected to

- 1.0 define and delimit problems to facilitate investigation [GCO 2]

Focus for Learning

An integral science skill involves identifying and defining topics or problems which require further investigation and determining limits or boundaries within.

The intent of this outcome is to evaluate student questions and then narrow the focus for investigation.

Students may have experience identifying problems and creating a purpose for an investigation, especially if they participated in a science fair. They should be able to state the problem and identify specific criteria for investigations, as well as identify constraints and limits to their investigation (e.g., defining a problem and not having sufficient equipment to investigate). Examples of how scientific investigations are limited by the evolution of technology and other constraints may be discussed at this point (e.g., the concentration of dissolved ions in water samples).

As an STSE connection, students may identify a variety of types of plastics utilized by society. To emphasize the importance of recycling plastics, students can identify and separate the plastics. This can be based on physical and chemical properties (e.g., separating based on density and combustion properties).

Initiating and Planning

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Share a video clip, article, or case study that highlights a current science related problem or crisis (e.g., using living ponds for mine tailings).
- Provide statements, quotations, or questions related to a topic. Ask each student (or group of students) to consider, discuss, and then share their thoughts (e.g., discuss the different technologies used in water treatment in communities throughout Newfoundland and Labrador).

Students may

- Participate in a brainstorming session to identify science related problems within the community, province, or country (e.g., how municipalities test water).

Connection

Students may

- Analyze the nutrition labels of several types of bottled water. Compare concentration of different ions. Discuss the pros and cons of bottled water.
- Research and list chemicals that may be found in a water supply. Determine how water samples are analyzed.
- Identify and define a problem, then list possible limitations or boundaries (e.g., quantitatively determine the concentration of certain ions using resources available in the school or community). This can be accomplished through participation in a school or regional science fair.

Consolidation

Teachers may

- Co-create with students, a set of criteria that may be used to assess whether an experiment can be designed to investigate the identified problem (e.g., whether components of an experiment are testable).

Students may

- Investigate the water quality in their own school or community. Collect water samples for analysis.
- Make recommendations on how to deal with water quality issues (e.g., hydration stations, rainwater collection).

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (Teacher Resource [TR])

Chemistry: Newfoundland and Labrador (Student Resource [SR])

- p. 399

Newfoundland and Labrador Teacher Resource & Solutions Manual (Digital)

Suggested

Resource Links: <https://bit.ly/2q0GY06>

- Brilliant Labs
- Curiosity
- Eastern Newfoundland Science and Technology Fair
- Khan Academy
- Let's Talk Science
- Newfoundland and Labrador Public Libraries

Initiating and Planning

Outcomes

Students will be expected to

- 2.0 design an experiment identifying and controlling major variables [GCO 2]

Focus for Learning

Students should be able to design and analyze a controlled experiment that investigates problems. After identifying the problem, students should brainstorm a list of specific variables to be considered. They should then consider the requirements of their investigation, including control variables, dependent variable, identification of required materials, independent variable, and sample size (replication).

When designing the investigation on the separation of plastics, students should collect data. They should use deductive reasoning to identify each type of unknown plastic and organize data in a neat table. It is also important that students control variables: size of plastic sample (e.g., 1 cm), temperature (since density is temperature dependant), size of test tube, and depth of liquid.

Since they often follow a cyclical process rather than a sequential one, investigations do not always begin by stating a hypothesis. An observation or an anomaly can result in an investigation even though the 'why' may be a point of discussion. Students should address limitations of their experimental design (e.g., access to equipment and other constraints).

When students design an investigation on percentage yield, teachers may suggest appropriate reactants such as a reaction of aqueous calcium chloride and aqueous sodium carbonate to produce aqueous sodium chloride and a precipitate of calcium carbonate. If guidance is needed, suggested procedural steps are listed below:

1. Weigh samples (e.g., 2.00 g) of each of the solids into two separate beakers. Add approximately 50 mL of water to each and stir to dissolve. Combine the two solutions.
2. Set up a filtration apparatus (funnel, retort stand, ring clamp, Erlenmeyer flask).
3. Fold a filter paper using proper technique, obtain and record its mass, then place in the funnel. Use a wash bottle of deionized water to wet the filter paper.
4. Slowly decant the reaction mixture into the filter paper, keeping the level of the solution below the paper's top edge.
5. Thoroughly rinse the beaker with deionized water and transfer to the filter. Thoroughly wash the contents of the filter.
6. Remove the filter paper with contents from the funnel and place on a watch glass to dry overnight.
7. Determine the mass of filter paper plus precipitate. Subtract this from the mass of the filter paper to determine precipitate yield.
8. Find, through calculation, the limiting reagent, the theoretical yield of precipitate, and the percent yield.
9. Describe two sources of error that would lead to a percent yield
a) greater than 100% b) less than 100%.

Initiating and Planning

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Discuss the Science 9 lab investigation on chemical and physical properties. Based on observations of the chemical and physical properties, students may have developed operational definitions for metals and non-metals.
- Discuss an experiment that investigates a particular issue and brainstorm possible variables that need to be controlled. For example, make a connection to Science 1206 and ask students to identify the independent, dependent, and control variables required to measure the effect of surface area on a reaction rate.

Connection

Teachers may

- Review the process that a scientist may use in designing an investigation.

Students may

- Discuss how current topics in Chemistry 2202 require further investigation (e.g., hydrogen bonding increases boiling points; however, this is not the only determining factor for boiling points as the interaction of several forces come into play).

Consolidation

Students may

- Design an investigation that deals with an issue within one science unit. Identify and explain how they intend to control variables. Complete the investigation (once approved by the teacher). For example, the teacher can provide students with an unknown chemical. Students can design an investigation to determine the properties of the unknown (provide each student or group of students with a different unknown chemical). Students can also identify all materials needed and provide step by step instructions for the procedure.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (SR)

- pp. 190-193 (Investigation)
- p. 399

Initiating and Planning

Outcomes

Students will be expected to

- 3.0 state a prediction and a hypothesis based on available evidence and background information [GCO 2]

Focus for Learning

Students will have previous knowledge in questioning, defining problems, and determining how to investigate those problems. This skill now requires students to make predictions and hypotheses based on available evidence and background information. In Science 7-9, students made predictions and hypotheses based on background information or an observed pattern of events.

Predictions are made in relation to testable questions. In investigations, students predict how a change in the independent variable will affect the dependent variable. Experimental predictions may be written as “If..., then...” statements. A common misconception is to assume hypotheses and predictions are simple guesses as opposed to being based on background evidence. Evidence should provide the basis from which students will make predictions and hypotheses.

Predictions supported by detailed reasoning are referred to as hypotheses; they explain predictions. Hypotheses may be written as “If..., then..., because...” statements. A hypothesis includes a prediction (i.e., “If..., then...”) and an explanation (i.e., “because...”). Predictions and hypotheses are supported or rejected by the evidence collected. In reality, the vast majority of scientific hypotheses fail. If performed appropriately, investigations are considered successful regardless of whether the evidence supports or rejects a hypothesis because something has been learned. For example, a student may be asked to predict which substances (from a list) would conduct electricity as a solid or which substances would produce precipitates when reacted.

To develop this skill, students should have opportunities to practice (with and without guidance). They should have a working knowledge of prediction or hypothesis writing. Project-based learning may help with the processes of predicting, hypothesizing, and connecting.

Initiating and Planning

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Perform a short inquiry demonstration. Ask students to predict what will occur and to explain their prediction (e.g., given a double replacement reaction, predict the precipitate that will form).
- Discuss the types of predictions that occur every day (e.g., weather, precipitation levels, temperatures).
- Observe several reactions where precipitates may or may not be formed. Ask students to develop general solubility rules.

Students may

- Choose an element from the periodic table. Based on its placement on the table, predict some of its properties.

Connection

Teachers may

- Share background information on a current chemistry topic or share data from a previous investigation. Discuss in relation to prediction and hypothesis.
- Provide stations with differing data sets and background. Ask students to move from one station to another, making written predictions based on available data. To compare and discuss predictions, a summary and group sharing may follow.

Students may

- Predict the conductivity of a variety of solids and aqueous solutions.

Consolidation

Students may

- Use data and background information during the completion of a lab investigation in order to state a prediction and hypothesis. List other pieces of evidence and information needed to determine whether the prediction could be more accurate.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (SR)

- pp. 114-136, 219-228
- pp. 216, 222 (Investigations)

*Initiating and Planning***Outcomes**

Students will be expected to

4.0 identify the theoretical basis of an investigation and develop a prediction and a hypothesis that are consistent with the theoretical basis
[GCO 2]

5.0 develop appropriate sampling procedures
[GCO 2]

Focus for Learning

It is important that students examine relevant theoretical information and then apply their knowledge to new situations. Based on the theoretical information involved, students should develop a prediction and a hypothesis.

Practical labs used to develop student understanding of scientific theory are the primary method for acquiring this skill. Teachers may guide at first; however, full student-based discovery is the goal.

Where appropriate, when conducting investigations, students should make a prediction and a hypothesis.

Students should understand that sampling is an important part of research since it can have a significant impact on the quality of experimental results. Repeat sampling requires students to use important skills during techniques such as use of proper pipetting when preparing a dilution, weighing a solid for solution preparation, or reading a meniscus from a volumetric flask. Accurate samples are key to good sampling.

Initiating and Planning

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Discuss the theoretical basis of Mendeleev's arrangement of the periodic table (i.e., not all elements were discovered, therefore, spaces were used in the host table). Share a video that outlines the development of the periodic table.

Students may

- Complete an admit slip to predict and make a hypothesis based on given theoretical information. Given an element name from the periodic table, and based on its placement on the table, predict some of its properties. An admit slip is a small slip of paper that is passed to each student upon entering the classroom; each piece of paper may have the same or different questions that will be answered and discussed.
- Discuss the following project that was completed in Mathematics 9: Students were introduced to sampling techniques. They developed and implemented a project plan for the collection, display, and analysis of data. They considered factors such as the collection method used; data reliability and usefulness of data; and the ability to make (from a sample) generalizations about the population. Students also described factors affecting the collection of data: bias, language use, ethics, cost, time and timing, privacy, and cultural sensitivity.
- Brainstorm and identify possible limitations of certain sampling equipment and procedures.

Connection

Students may

- Identify areas where a theory is used to predict outcomes (e.g., compounds are predicted from reactants–bonding theory).
- Predict, given two atoms bonded together, the type of bonding (molecular, ionic, network covalent) that would occur and the properties of the new compound.
- Discuss an experimental activity. Indicate why a particular sampling procedure was used and why it was appropriate in this situation.

Consolidation

Students may

- Design and complete an investigation based on a theory they create or read about. Establish a hypothesis and predict the outcome based on that theory.
- Predict the procedure for an investigation. Before carrying out the investigation, justify instrument choices.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (SR)

- pp. 114-136, 266-301
- p. 294 (Investigation)

Performing and Recording

Outcomes

Students will be expected to

- 6.0 implement appropriate sampling procedures [GCO 2]

Focus for Learning

In the application of this skill, the context will determine the appropriate procedures (e.g., use of a volumetric flask vs. a graduated cylinder or beaker for the preparation of a standard solution).

Experiential reinforcement is necessary for this skill to be properly developed.

When conducting sampling procedures, it is important to adhere to standardized procedures that allow for repeatability. Depending on the nature of the investigation, students should ensure proper selection of equipment in order to meet specific sampling requirements. Equipment selection may include

- balance,
- beaker(s),
- funnel,
- pipette (volumetric/delivery, graduated),
- stirring rod,
- thermometer,
- volumetric flask, and/or
- weighing vessel (weigh boat or small beaker).

When conducting any lab investigation, teachers should review safety considerations appropriate for the activity. These should include post-lab clean up and the appropriate disposal of products formed. Teachers can refer to and direct students to use Safety Data Sheets (SDS) to identify all risks associated with the chemicals in use.

Students should recognize that when two aqueous ionic solutions react, there is a possibility that a precipitate will form. They should be able to use the solubility rules to identify a precipitate.

Performing and Recording

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Review probability (random selection sampling) and non-probability sampling (use the subjective judgement of the researcher to select the sample).
- Discuss:
 - Random sampling
 - Representative sampling
 - Importance of avoiding contamination

Connection

Teachers may

- Demonstrate a gas collection lab investigation. Emphasize proper technique when collecting a gaseous product as opposed to a precipitate.

Students may

- Identify problems with an experimental design where variables require manipulation (e.g., solubility: in a solution, keeping temperature and pressure controlled while varying the amount of solute).

Consolidation

Teachers may

- Demonstrate and discuss capabilities of different instruments. For example, discuss why, in collecting the sample for the preparation of a diluted solution, a pipette is chosen over a graduated cylinder.

Students may

- Use the following tests to confirm oxygen or hydrogen gas as a product of a chemical reaction:
 - A glowing splint will reignite if oxygen gas is present.
 - A lit wooden splint will make a pop if hydrogen gas is present.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (SR)

- pp. 114-136

Performing and Recording

Outcomes

Students will be expected to

- 7.0 use instruments effectively and accurately for collecting data
[GCO 2]

Focus for Learning

It is important that teachers demonstrate the proper techniques necessary for effective use of any instrument or piece of equipment. Students should identify potential sources of error caused by improper use of instruments and be able to discuss how the accuracy of data collection may vary depending on instruments used. After data collection is complete, a review of any discrepancies between student results should be discussed and related back to the importance of using instruments effectively and accurately.

Frequent use of laboratory instruments is necessary for students to properly develop important skills. Students should have numerous opportunities to practice use of appropriate instruments during daily class routines (e.g., appropriate use of pipettes).

Students should be able to apply appropriate weighing techniques such as taring a balance and weighing by difference. They should be able to use both methods and choose the most appropriate method for a particular situation.

When weighing any reagent from a bottle, it is important that students not contaminate the stock bottles. They should recognize that it is inappropriate to place a scoopula (or any instrument) into a stock bottle. If a student weighs extra reagent, the excess should not be placed back into the container.

Students should be able to collect a precipitate using appropriate filtration techniques. A filtration apparatus consists of a funnel, a stand, a ring clamp, an Erlenmeyer flask, and filter paper.

Students should also be able to create a precise volume of solution using a volumetric flask. They should be able to describe a meniscus and accurately read glassware that contain meniscus.

Performing and Recording

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Demonstrate the use of devices such as electronic balance, volumetric flask, pipette, graduated cylinder. For example, describe and demonstrate the proper use of a volumetric flask. An accepted technique for improving accuracy involves the proper reading of the meniscus.

Students may

- Choose an investigation or a component of an investigation. Discuss and differentiate between accuracy and precision (e.g., during solution preparation).

Connection

Teachers may

- Discuss
 - the rationale for fluting a filter paper (that the folds increase the surface area available for filtration), and
 - issues associated with improperly fluting filter paper.
- Demonstrate how to properly fold (flute) a filter paper.
- Demonstrate how to read a meniscus at eye level.

Students may

- Use an electronic balance to help demonstrate how to weigh a sample mass accurately. Comment on instrument use within the procedure and make recommendations on how it can be more effective.

Consolidation

Students may

- Reflect on their own use of instruments. Gather feedback from classmates regarding observations of instrument use.
- Perform an alternate lab that produces a precipitate (that can be filtered) from aqueous and gaseous reactants such as:

$$\text{Ca(OH)}_2(\text{aq}) + \text{CO}_2(\text{g}) \rightarrow \text{CaCO}_3(\text{s}) + \text{H}_2\text{O}(\text{l})$$
 - To produce the gaseous reactant, carbon dioxide, students would have to perform a preliminary reaction with baking soda and vinegar. This would be either in a stoppered test tube or Büchner flask (suction flask) with a piece of rubber tubing that leads into the calcium hydroxide solution. The carbon dioxide gas will then flow through the tubing and will react with the calcium hydroxide solution. Suggested quantities: 200 mL of 0.100 M Ca(OH)_2 , 2.0 g of baking soda, and 30.0 mL of vinegar.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (SR)

- pp. 49-81
- pp. 70, 103-107 (Investigations)

Performing and Recording

Outcomes

Students will be expected to

8.0 estimate quantities
[GCO 2]

Focus for Learning

Estimating quantities may be useful when obtaining a highly precise value is impractical, approximations are adequate, or as a rough check for success. Estimation helps develop understanding of the problem in the study. Errors in estimation reinforce the importance of quantification. Students have prior experience with estimation; this comes from previous and current mathematics courses. The difference in calculating versus estimating may need to be reviewed.

Various methods of estimation used within science should be introduced. These may include those listed below:

- Extrapolation
- Interpolation
- Guess and Check
- Trial and Error

The last two have particular use in experimentation.

In Chemistry 2202, it is important to note that estimation of quantities will have consequences for both precision and accuracy of results.

Students also have previous experience in estimating measurements. Estimating helps students select the appropriate tool for a task. For example, different spring scales measure different capacities.

Estimating prior to measuring also helps students determine whether the measurement is reasonable. For example, estimating the temperature on an October morning to be 5.5 °C and then finding the actual thermometer reading to be 34.5 °C, is cause to question the accuracy of the thermometer or the way it is being used.

Performing and Recording

Sample Teaching and Assessment Strategies**Activation**

Teachers may

- Discuss difficulties that some science students may have with estimation.

Students may

- Brainstorm and discuss common examples of estimation that occur in their lives. For example, we estimate weather on a daily basis: temperature, rainfall, snowfall, wind speed, etc.
- Estimate the temperature in the room. Discuss the process and techniques used.

Consolidation

Students may

- Identify estimations made in a lab investigation. Indicate why the estimation was made, its form, and how it compared to the measured or accepted value.

Resources and Notes**Authorized**

Chemistry: Newfoundland and Labrador (SR)

- pp. 103-107 (Investigation)

Performing and Recording

Outcomes

Students will be expected to

- 9.0 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data
[GCO 2]
- 10.0 use library and electronic research tools to collect information on a given topic
[GCO 2]
- 11.0 select and integrate information from various print and electronic sources or from several parts of the same source
[GCO 2]

Focus for Learning

Data can be collected using a variety of technologies and can be organized as charts, tables, notes, log books, or digital files. Mobile wireless devices allow for image collection, spreadsheet creation, data analysis, and peer collaboration. When collecting data, students should consider significant digits and units. See Appendix A for information on scientific conventions.

The intent is that students create their own recording forms and data tables. In order for teachers to assess SCO 9.0, students should be able to compile and organize large data sets.

The intent of this outcome is to use appropriate research inquiry techniques to collect information. Students will have also developed these skills in other curriculum areas.

Teachers should review relevant, acceptable use of library and electronic research tools, practices, and policies. Students will continue to develop practical skills necessary to evaluate the degree of validity, reliability, and bias of a source. They should be able to determine origin of material and check sources for appropriateness, organized links, and accessible information. They should also be able to use advanced search techniques and keywords.

A review of the following may be necessary:

- Acceptable types of information and sources
- Citation and reference guidelines
- Rules regarding plagiarism

Students should continue to develop strategies related to selecting, organizing, and integrating information that is gathered.

To develop these skills, students can focus on Chemistry 2202 topics:

1. Research properties of molecular compounds and explain (using an appropriate form such as a diagram, paragraph, etc.) how intermolecular forces contribute to those properties. Properties can include shape, density, melting point, boiling point, electrical conductivity, solubility, physical state, surface tension, hardness, and texture.
2. Research and select appropriate information from sources as it relates to organic chemistry. For example, there are many claims about the associated health effects of various organic substances. One category of organic compounds includes volatile organic compounds (VOCs) which are a key ingredient in fuels, paints, sprays, solvents, etc. (common material that many people have at home). Students should be able to critique various sources, as well as gather and interpret information regarding VOC and chemicals that are classed as VOC's, while not limiting themselves to online resources. Ideas are not limited to VOCs and can therefore include different topics related to technology, society, and the environment.

Performing and Recording

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Discuss the most efficient ways to organize data (that includes significant digits and units).
- Review research and citing protocol.
- Invite a representative from NLPL (Newfoundland and Labrador Public Libraries) to provide an overview of NLPL services and databases. Request library cards for students.

Students may

- Brainstorm ways to organize large sets of data. Compare the effectiveness of each in relation to a specific data set.
- Discuss topics from previous science courses on which they or their classmates conducted research.
- Discuss the importance of having reliable and valid sources when conducting research (a reliable source may not be valid).

Connection

Students may

- Create two different recording forms to report the same set of data. For example, record all the plastics they use in one week. Reflect on and share ways they can reduce, reuse, and recycle.
- Use inquiry to determine how types of plastics are classified.
- Research how other provinces address the recycling of materials. Compare to Newfoundland and Labrador practices.
- Find and share examples of misinformation. Discuss how the information may have been shared.
- Research and share non-conventional ways of reusing materials.
- Research common substances based on their physical properties as related to the type of bonding involved in the substance (e.g., diamonds used in drilling, copper used in wiring, graphite vs. graphene). Explain why they are used.

Consolidation

Students may

- Work in a group to choose a molecular compound. Individually research a different property of that compound, then consolidate findings with those of other group members.
- Research one component of a lab investigation. Generate a list of questions that arise.
- Research a lab investigation topic (e.g., other ways of expressing concentration). Share findings.
- Research and present a complete recycling process (i.e., what happens to materials that are recycled and how they are reused).

Resources and Notes

Authorized

Appendices

- Appendix A: Scientific Conventions

Chemistry: Newfoundland and Labrador (SR)

- pp. 190-193, 259 (Investigations)
- pp. 231-251, 390-392

Performing and Recording

Outcomes

Students will be expected to

12.0 select and use apparatus and materials safely
[GCO 2]

13.0 demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials
[GCO 2]

Focus for Learning

When conducting any lab investigation, teachers should review applicable safety considerations as well as demonstrate proper handling techniques and use of equipment. Students should be able to select and use materials safely.

Students should be familiar with the safe and appropriate use of an electronic balance, a hotplate, glassware, a funnel/filter paper, and a thermometer. Students should also be able to properly clean and dry equipment.

Teachers should assess whether students are using apparatus and materials safely. Types of assessment may include checklists, observations, peer evaluations, etc.

To be able to make appropriate choices, students will need practical experience. An overview of safety policies and correct procedures in laboratory environments is required before students participate in any activity or investigation. This should be part of the school safety plan and should be reviewed on an annual basis.

Students will have previous experience with Workplace Hazardous Materials Information System (WHMIS); however, due to its importance, a pre-assessment will determine student level of proficiency. Teachers should demonstrate WHMIS standards and the proper techniques required when handling and disposing of materials.

An overview of specific WHMIS and safety procedures should be completed before any investigation takes place. For example, a review of acid safety or hotplate safety should be completed before students use either of these.

Students should be assessed on their ability to demonstrate WHMIS handling knowledge during lab investigations.

When designing the investigation on the separation of plastics, students should recognize the safety concerns of burning plastics. For example, during the teacher demonstration, it is important to burn only a very small sample (e.g., 1-2 cm) of plastic using tongs/ tweezers in a fume hood and over a watch glass. The Safety Data Sheet (SDS) should be consulted for chosen liquids.

Performing and Recording

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Demonstrate safe use of lab equipment and materials while abiding by current WHMIS (2015) standards. This may be completed on an as needed basis, or can include a designated set of equipment to be used throughout the year. Assessment of student understanding in this instance is also required.

Students may

- Set up an investigation and demonstrate proper safety procedures including appropriate storage and disposal.

Connection

Students may

- Develop safety signs for the lab; emphasize content specific to Chemistry 2202.
- Create safe operating procedure quick sheets for lab equipment and materials.
- Outline WHMIS guidelines on posters. Display in the lab.

Consolidation

Students may

- Develop a mix and match game using WHMIS symbols and the meaning of each.
- Safely handle and dispose of acids and bases.
- Present WHMIS guidelines to a group of younger science students.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (SR)

- pp. 49-81, 399
- pp. 70, 103-107 (Investigations)

Analyzing and Interpreting

Outcomes

Students will be expected to

14.0 describe and apply classification systems and nomenclatures used in the sciences

[GCO 2]

15.0 identify limitations of a given classification system and identify alternative ways of classifying to accommodate anomalies

[GCO 2]

Focus for Learning

Classification systems are human constructs that attempt to make sense of the physical world. Examples of classification systems in Chemistry 2202 include concepts such as classifying compounds, identifying reaction types, and naming acids and hydrates.

Teachers may explain how scientists can communicate using standardized systems of organization, grouping, and naming. Teachers may also use examples of how common terms aid in collaboration and understanding. For example, chemists use common nomenclature to identify and name chemical compounds.

Students should have opportunities to use such classification systems and nomenclature, specifically during an investigation.

Discoveries, new technologies, and reorganization may cause alteration of current nomenclatures and classifications. Teachers should note and discuss how classification systems can be confusing (e.g., network covalent solids and acids do not share the properties of all molecular compounds).

Analyzing and Interpreting

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Describe examples of systems of classification or organization. The periodic table is an example from Science 9 which demonstrates how elements are organized based on their properties. Other examples include rock classification, chemical naming, metal versus non-metal, acids and bases.
- Discuss reasons why common names are used. Ask students to offer suggestions as to the common name for
 - 1,3,7,-trimethyl1-3,7-dihydro-1H-purin-2,6-dione.

Connection

Teachers may

- Discuss how the discovery of new species, elements, and planets have disrupted classification systems and resulted in reorganization or reclassification.

Students may

- Brainstorm and discuss course specific examples of classification systems (e.g., molecular/ionic compounds, metals/non-metals, acids/bases).
- Investigate chemicals having common names and suggest reasons why common names are used in place of the IUPAC name.
- Participate in an activity called Chemical Poker. Apply the IUPAC rules for creating and naming ionic compounds. This activity uses cards representing ions and subscripts to create chemical formulas and name the created ionic compound.
- Create a graphic organizer (e.g., Venn diagram) or a dichotomous key to help identify compounds as molecular, network covalent, or ionic.
- Research network covalent solids to learn more about molecular (covalent) substances. For example, research the differences in graphite, graphene, diamond, and buckminsterfullerene, or research advances in nanotechnology. Share findings with the class.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (SR)

- pp. 17-22, 31-42, 277-280, 328-330, 348-351

Analyzing and Interpreting

Outcomes

Students will be expected to

16.0 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots
[GCO 2]

17.0 identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty
[GCO 2]

Focus for Learning

Communication must reflect ideas, plans, and results accurately and without bias. Students have previously represented data in a variety of ways and should continue to develop skills associated with data representation. This may include using diagrams, models, charts, graphs, and various statistical figures.

Teachers should emphasize the use of clear and concise modes of representation that appropriately and accurately reflect results of a student oriented investigation. Use of numbers, symbols, graphs, and language is pervasive across the sciences; therefore, opportunities to demonstrate proficiency are necessary.

Tables are often used to compile data while graphs and charts are used to interpret and present this data. Tables should include both rows and columns with appropriate headings. A descriptive title that includes a number (e.g., Table 1: Title) should be located at the top.

Diagrams, charts, and graphs provide a means to present trends in collected data. These would be considered figures and should be numbered with a descriptive title included at the bottom (e.g., Figure 1: Title/description). Additionally, the x and y axis of a graph should be clearly labelled with the appropriate units and with the x-axis containing the independent variable.

Significant digits should be an important part of this discussion, as well as different types of error (such as random or systematic error).

One of the most difficult parts of designing an investigation is to control or account for all possible factors except the one independent variable that is being studied.

Teachers should demonstrate variability in the measuring process due to errors from instrumentation and procedures. Instrument failure and human error (e.g., technique) are common examples.

After activities have been completed, teachers should hold a debriefing session (either in small groups or as a whole class) to address discrepancies in results from different groups of students. Brainstorming possible reasons for the discrepancies, sources of error, and uncertainty in measurement, can help students critically reflect on their practices and make notes for improvement during subsequent activities.

Analyzing and Interpreting

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Discuss the importance of including a title, labelling an axis, and choosing an appropriate scale.
- Demonstrate how using a lab thermometer to measure the temperature of water as it is heating can produce sources of error. Ask students to develop a list of potential errors that result from improper usage. Other apparatus that should be discussed include scales, meter sticks, and graduated cylinders.

Students may

- Brainstorm examples of appropriate use of line graphs, circle graphs, and scatter plots to organize and display data. Each of these formats is also a component of intermediate mathematics courses.

Connection

Teachers may

- Highlight and discuss typical graphing errors (e.g., choosing inappropriate type, incorrect scaling).
- Discuss reasons why percent yield may be less than or greater than 100%.

Students may

- Justify use of a particular data format and display in an experiential activity. Indicate why the format was appropriate and how it aided in the interpretation of the data. For example, determining whether molecules are polar or non-polar is more clearly understood when the shapes are represented by 3-D models.
- Identify and explain ways that error can be reduced in experimentation. During an investigation, apply appropriate methods to increase the reliability of data collection methods.
- Record their lab investigations. View and identify possible sources of error.

Consolidation

Students may

- Interpret patterns and trends in data by using a visual representation such as a line graph. As part of the interpretation, infer relationships within the data. For example, populate a graph with shapes, names, and diagrams of different molecular substances.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (SR)

- pp. 190-193, 216, 222, 259, 288, 292-295 (Investigations)
- pp. 219-228, 231-251, 281-289

Analyzing and Interpreting

Outcomes

Students will be expected to

18.0 identify and apply criteria, including the presence of bias, for evaluating evidence and sources of information
[GCO 2]

19.0 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion
[GCO 2]

20.0 explain how data support or refute the hypothesis or prediction
[GCO 2]

Focus for Learning

Critical thinking is important for the scientific process and for the development of investigations that produce credible results. Data collection within a study is conducted to test a hypothesis, not to confirm a belief. Students should be shown examples of how bias interferes with the scientific investigative process.

To ensure accuracy and credibility, scientific investigations are often replicated numerous times. The goal of many scientists is for their work to be highlighted in a peer reviewed journal. Scrutiny and critiques are part of all research practice and results. If this is not present, then scientists can introduce bias and make any number of unproven claims.

This outcome has specific cross-curricular applicability to English (language arts) 1201, 2201, and 3201.

Students should be able to

- draw conclusions which answer investigative questions, and
- provide solutions to problems explored.

Conclusions should be based on data obtained from student investigations. Results obtained should be compared to predictions and results of other students. Conclusions should include comments on experimental error.

Students should compare the data collected to the testable hypothesis. They should then determine whether the data is sufficient to produce a decision to reject or accept the hypothesis or whether modification of the data collection is required to better address the hypothesis.

Students should provide more information than a statement on the acceptance or rejection of their hypothesis. They should be able to answer the 'because' part and provide an analysis of their data in order to explain why their hypothesis was either accepted or rejected.

Analyzing and Interpreting

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Use specific examples to discuss information often reported by news media. How reliable is the source? How accurate is the information? Does it provide a clear picture? Where else can you go to find more accurate information? Do you question the message? What other questions are not answered?
- Review geocentric versus heliocentric universe view (Science 9).
 - Copernicus was brave to suggest the Heliocentric view of the universe during his time. Why? What biases were present at that time to make this a brave suggestion?
- Demonstrate how to evaluate data to either support or reject a hypothesis.

Students may

- Use data developed from the lab investigation, 'Determining the Best Conditions for Yeast Production' to identify the link between the data and optimal yeast growth conditions.

Connection

Teachers may

- Provide students with access to a scientific journal such as *Nature*. Discuss why peer review is important in scientific studies.

Students may

- Gather information on the organic molecule, aspartame. Determine why Pepsi™ banned aspartame in the US, but not in Canada.
- Determine what evidence is used to support the conclusion that all metals conduct electricity or all ionic compounds are solid.

Consolidation

Students may

- Complete a formal lab report which involves evaluating evidence, stating conclusions, and using available data to support the conclusion.
- Research the organic molecule, methyl mercury, to explore why there is controversy surrounding its production. Determine what bias is involved in the controversy (based on the information source).

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (SR)

- pp. 49-81, 390-392
- pp. 70, 190-193 (Investigations)

Analyzing and Interpreting

Outcomes

Students will be expected to

21.0 identify and correct practical problems in the way a technological device or system functions
[GCO 2]

Focus for Learning

Technology devices used in Chemistry 2202 may include electronic balance, filter paper, funnel, glassware, hotplate, probeware and thermometer. Through use, students should identify practical problems and devise solutions to correct those problems.

For example:

1. Students should identify the need for calibration when using measuring instruments.
2. Students should identify technology malfunction, poor technique, and improper use of apparatus as problems that can alter results. Protocols for making adjustments should be consistent with those approved within the scientific community.
3. Students should identify that there is inaccuracy in the volume measurements of glassware. The accuracy for each piece of equipment is accessible and can be discussed with students; A 250 mL volumetric flask is accurate to ± 0.15 mL (depending on the lab grade). To improve accuracy of measurement, students should choose the right equipment when performing any investigation; a pipette is more accurate for measuring volume than a graduated cylinder.

Analyzing and Interpreting

Sample Teaching and Assessment Strategies**Activation**

Teachers may

- Review portions of Science 7 (Heat unit) to determine students' prior knowledge and experience in selecting appropriate methods and tools to construct and test a thermometer. Review the data collected in the testing of the design.
- Develop and assign a design challenge for groups of students to
 - complete an investigation,
 - share results, and
 - identify and correct problems associated with the investigation.

Connection

Teachers may

- Ask students to discuss
 - the best method to determine the mass of a solid: taring or weighing by difference, and
 - the better technique to determine the amount of a liquid reactant: weighing it or determining its volume.

Students should explain their choice in each instance.

Consolidation

Students may

- Compare the percent discrepancy on glassware in their science lab. Discuss each piece in terms of its appropriateness when completing qualitative and quantitative investigations.
- Research and list types of equipment that are available in research laboratories. Compare the percent discrepancies.

Resources and Notes**Authorized**

Chemistry: Newfoundland and Labrador (SR)

- pp. 49-81, 137-142
- p. 70 (Investigation)

Communication and Teamwork

Outcomes

Students will be expected to

22.0 communicate questions, ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others
[GCO 2]

Focus for Learning

Science is not only an academic learning experience for students, it is also a social learning experience. It is important for students to develop a sense of positive interdependence with each other. Communication and collaboration skills are central to developing that interdependence. Sending and receiving information effectively as well as working together are important skills for students in all school experiences and beyond. Students continue to develop communication and collaboration skills in all subject areas through a range of activities and strategies. Emphasis should be placed on how equally important it is to be able to listen and respond appropriately to questions while providing positive feedback.

Teacher modelling of effective skills is important. Teachers should use relevant chemistry and science related examples to discuss and model skills associated with listening and speaking in any format, and in any setting. For example, teachers can demonstrate through the use of molecular modelling kits. When investigating isomers, teachers may propose specific hydrocarbons for groups of students to create and name. Groups can exchange models to confirm whether it is an isomer (by naming the compound and determining its chemical formula). Similarly, given different structural diagrams of the same isomer, students can critique and communicate (in small and large groups) why different diagrams are actually the same isomer.

Communication and Teamwork

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Provide opportunities for students to work in pairs and small groups to consider, discuss, question, and then reach their own conclusions on specific topics and issues.
- Share relevant science related articles. Ask students to read, note key ideas and questions, and share their findings in a small or large group.

Students may

- Brainstorm ideas related to characteristics of effective communication (e.g., what it looks like in various settings, strategies that students can use to communicate effectively).

Connection

Teachers may

- Facilitate a discussion on the daily use of organic compounds.

Students may

- Work in a small group to prepare and share information on a chemistry related topic. As a group, reflect on the effectiveness of the manner in which information was shared.
- Choose a controversial product or idea (e.g., the use of pesticides). Participate in a debate continuum (students will place themselves along the continuum in support or nonsupport). Each side can debate their rationale for supporting or not supporting, after which students may choose to move to a different location on the continuum. Students who have changed their opinion may have an opportunity to elaborate on the reasons for their choice.

Consolidation

Students may

- Research and communicate how aspects of organic chemistry relates to their lives (e.g., research various chemicals or products such as medicine, plastics, clothing, household material). Communicate the name of the product, its physical and chemical properties, its use, and any effects it has on their lives.
- Ask another student to describe how they completed a specific lab investigation. The listener can offer advice to improve technique and outcome.
- Choose a topic. Research claims and support or refute ideas. Some examples include leaching in plastic water bottles, use of aspartame, and the use of pesticides on produce.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (SR)

- pp. 190-193, 314, 327, 363 (Investigations)
- p. 314

Communication and Teamwork

Outcomes

Students will be expected to

23.0 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results
[GCO 2]

Focus for Learning

Students should have opportunities to record data in a variety of ways. Students will further develop skills associated with this by determining the appropriate form to represent data, as well as using diagrams, models, charts, graphs, and various statistical figures. Teachers should emphasize the use of clear and concise modes of representation that accurately reflect results of a student oriented investigation.

This has significant applicability in high school science as accuracy in significant figures, units, nomenclature, and terminology is important for the understanding of many concepts. See Appendix A for information on scientific conventions.

Students should be able to explain how use of numbers, symbols, graphs, and language allows scientists to communicate using a standardized system of organization, grouping, and naming. Teachers may use examples of how common language aids in collaboration and understanding. For example, chemists use common nomenclature to identify and name chemical compounds.

Teachers should ensure that students have opportunities to use such classification systems and nomenclature, specifically in an investigation. Knowledge and development of such skills will be further refined through activity. For example, students could discuss how to operationally identify an unknown acid or base.

Communication and Teamwork

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Discuss the results of a 0% yield activity. Emphasize how the results would need to be communicated.

Students may

- Collect or be provided with data from a previous lab investigation. In groups, discuss and determine how best to present results. In each instance, justify the use of numeric, symbolic, graphical, and linguistic modes of communication.

Connection

Students may

- Consider the presented results from the previous activity. Use a different set of numbers, symbols, graphs, and language to describe the results. Compare the two methods. Determine which was most effective and list reasons for their choice. For example, students could use a table and a graph to present data. What are the pros and cons of each method of presenting results?

Consolidation

Students may

- View recordings of their lab investigations. Assess their own proficiency in communication and collaboration.
- Self-assess or peer assess a formal lab report. Focus on science communication, units, significant figures, etc.

Resources and Notes

Authorized

Appendices

- Appendix A: Scientific Conventions

Chemistry: Newfoundland and Labrador (SR)

- pp. 216, 222, 288, 292-295 (Investigations)
- pp. 219-228, 281-289

Communication and Teamwork

Outcomes

Students will be expected to

24.0 synthesize information from multiple sources or from complex and lengthy texts and make inferences based on this information
[GCO 2]

25.0 develop, present, and defend a position or course of action, based on findings
[GCO 2]

Focus for Learning

Information gathered from different sources can be synthesized to form a well-rounded explanation or argument. Synthesizing information is a skill that will develop students' ability to determine relationships and connections among different sources. It is necessary in order to form conclusions with pre-existing data. Having the ability to synthesize information will enable students to strengthen decision making and argumentation skills. It will also strengthen students' ability to make inferences and offer plausible explanations.

In developing this skill, it may be necessary to begin with simple, limited sources. Further development may increase the level of complexity of sources, or the number of sources from which information can be gathered. Teachers should emphasize the importance of evaluating sources in terms of accuracy and reliability.

Mathematics 2201 and English language arts curriculum guides both provide suggestions on working with sources of information.

In conjunction with synthesizing information, students may develop an argument, position, or plan of action. Critical thinking, abstract thinking, and communication skills will develop as a result of presenting, debating, and defending information.

Students should have opportunities to present their own positions, present the positions of others, and offer rebuttals. These can be completed as debates, role plays, impromptus, prepared discussion points, etc. Student opportunities to present in the science classroom are important for developing communication skills and can be used in a cross-curricular manner with academic mathematics (inquiry project) and English language arts.

Communication and Teamwork

Sample Teaching and Assessment Strategies

Synthesis and inference are two elements of critical thinking. These are also required to review sources for validity and reliability.

Activation

Teachers may

- Review primary and secondary sources, requirements for documentation, and plagiarism (may be supported by other curriculum areas).

Students may

- Participate in a classroom discussion involving the accuracy and validity of information available on social media. Discuss reliability and reputation of sources and the importance of researching beyond the source. Consider: What would be necessary for you to believe in information right away?

Connection

Teachers may

- Introduce a science-related problem. Use the Issues and Stakeholders Learning Strategy to identify and discuss different perspectives on a topic.

Students may

- Use the organic molecule, aspartame. Search links to methanol poisoning during the Gulf War (and other instances). Produce an argument for its use (or non-use). Note: Aspartame is one of the most researched chemical compounds.
- Use a variety of sources to research a specific science-related problem. Defend a course of action to solve the problem.
- Use a cost-benefit analysis strategy to identify the costs (disadvantages, downsides, financial burden) and benefits (advantages, upsides) of a specific issue or topic. Consider the advantages and disadvantage of scientific related problems such as the use of plastic versus fibre products.

Consolidation

Students may

- Work in groups. Half of the students in each group will investigate properties of molecular compounds while the other half will investigate ionic compounds. Groups will then work together to combine data, methods, and conclusions to present one theory (re: properties of compounds).

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (SR)

- pp. 107, 390-392

Section Three:
Specific Curriculum Outcomes

Unit 1: Stoichiometry

Focus

Stoichiometry is the calculation of quantities of reactants and products in chemical equations. Students will learn about this quantitative concept which is used to determine the product that will be formed or produced from a given quantity of reactants. They will apply chemical principles to their own surroundings and compare properties of different kinds of solutions using various technologies.

Scientific inquiry is an important component of this unit. Inquiry-based learning opportunities involving the nature of solutes, solvents, the mole concept, balancing equations, and stoichiometry, enable students to better understand the nature of chemical reactions.

Emphasis is placed on the development of skills related to posing questions, making predictions, making and recording observations and measurements, analyzing and interpreting recorded data to identify emerging patterns, and communicating learning.

Outcomes Framework

GCO 1 (STSE): Students will develop an understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology.

- 28.0 explain the roles of evidence, theories, and paradigms in the development of scientific knowledge
- 29.0 explain how a major scientific milestone revolutionized thinking in the scientific communities
- 30.0 analyze and describe examples where scientific understanding was enhanced or revised as a result of the invention of a technology
- 34.0 compare processes used in science with those used in technology
- 35.0 analyze society's influence on scientific and technological endeavours
- 41.0 identify various constraints that results in trade-offs during the development and improvement of technologies
- 42.0 identify and describe science-and technology-based careers related to the science they are studying

GCO 2 (Skills): Students will develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions.

- 2.0 design an experiment identifying and controlling major variables
- 3.0 state a prediction and a hypothesis based on available evidence and background information
- 5.0 develop appropriate sampling procedures
- 6.0 implement appropriate sampling procedures
- 7.0 use instruments effectively and accurately for collecting data
- 8.0 estimate quantities
- 9.0 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data
- 12.0 select and use apparatus and materials safely
- 13.0 demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials
- 14.0 describe and apply classification systems and nomenclatures used in the science
- 17.0 identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty
- 19.0 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion
- 20.0 explain how data support or refute the hypothesis or prediction
- 21.0 identify and correct practical problems in the way a technological device or system functions
- 22.0 communicate questions, ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others

GCO 3 (Knowledge): Students will construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge.

- 26.0 write and name the formulas of ionic and molecular compounds, following simple IUPAC rules
- 27.0 define molar mass and perform mole-mass inter-conversions for pure substances
- 31.0 explain solubility, using the concept of equilibrium
- 32.0 define the concept of equilibrium as it pertains to solutions
- 33.0 explain the variations in the solubility of various pure substances, given the same solvent
- 36.0 use the solubility generalizations to predict the formation of precipitates
- 37.0 identify mole ratios of reactants and products from balanced chemical equations
- 38.0 perform stoichiometric calculations related to chemical equations
- 39.0 predict how the yield of a particular chemical process can be maximized
- 40.0 identify various stoichiometric applications

GCO 4 (Attitude): Students will be encouraged to develop attitudes that support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society, and the environment.

Students are encouraged to:

- value the contributions to scientific and technological developments made by people from many societies and cultural backgrounds
- consider further studies and careers in science-and technology-related fields
- value the processes for drawing conclusions
- project the personal, social, and environmental consequences of proposed action
- want to take action for maintaining a sustainable environment
- show concern for safety and accept the need for rules and regulations

SCO Continuum

GCO 3: Knowledge		
Science 9 and Science 1206	Chemistry 2202	Chemistry 3202
<p>Science 9</p> <ul style="list-style-type: none"> identify and write chemical symbols or molecular formulas of common elements or compounds <p>Science 1206</p> <ul style="list-style-type: none"> name and write formulas for some common ionic and molecular compounds, using the periodic table and a list of ions classify substances as acids, bases or salts, based on their characteristics, name, and formula represent chemical reactions and the conservation of mass using molecular models and balanced symbolic equations classify chemical reactions based on type illustrate how factors such as heat, concentration, light, and surface area can affect chemical reactions 	<ul style="list-style-type: none"> write and name the formulas of ionic and molecular compounds, following simple IUPAC rules define molar mass and perform mole-mass inter-conversions for pure substances explain solubility, using the concept of equilibrium define the concept of equilibrium as it pertains to solutions explain the variations in the solubility of various pure substances, given the same solvent use the solubility generalizations to predict the formation of precipitates identify mole ratios of reactants and products from balanced chemical equations perform stoichiometric calculations related to chemical equations predict how the yield of a particular chemical process can be maximized identify various stoichiometric applications 	<ul style="list-style-type: none"> describe various acid-base definitions up to and including the Brønsted-Lowry definition define the concept of dynamic equilibrium as it pertains to reversible chemical reactions calculate the pH of an acid or a base given its concentration, and vice versa compare strong and weak acids and bases using the concept of equilibrium (mathematical) explain how acid-base indicators function describe the interactions between H_3O^+ ions and OH^- ions using Le Châtelier's principle predict products of acid-base reactions write and balance thermochemical equations including the combustion reactions of alkanes compare oxidation-reduction reactions with other kinds of reactions explain the processes of electrolysis and electroplating determine the concentration of an acid or base solution using stoichiometry

Suggested Unit Plan It is recommended that Unit 1: Stoichiometry, be completed as the first unit of Chemistry 2202.

September	October	November	December	January	February	March	April	May	June
Unit 1: Stoichiometry				Unit 2: From Structures to Properties			Unit 3: Organic Chemistry		
Skills Integrated Throughout									

Classifying Compounds

Outcomes

Students will be expected to

26.0 write and name the formulas of ionic and molecular compounds, following simple IUPAC rules
[GCO 3]

14.0 describe and apply classification systems and nomenclatures used in the sciences
[GCO 2]

Focus for Learning

In Science 1206, students were expected to write IUPAC chemical formulas when given the name (or vice versa) for both ionic and molecular compounds. Ionic compounds included simple ionic, multivalent, and those that contain polyatomic ions. Ionic hydrates were NOT addressed in Science 1206. In Chemistry 2202, students should be able to apply the rules for writing formulas and for naming ionic hydrates.

While systematic IUPAC naming is important for scientists to communicate effectively and to work safely, trivial names continue to be commonly used for certain compounds. From Science 1206, students should name and write formulas for the following:

- $C_6H_{12}O_6$ – glucose
- H_2O – water
- H_2O_2 – hydrogen peroxide
- O_3 – ozone
- NH_3 – ammonia

Teachers may review naming from Science 1206 as it will provide a foundation for this unit and for the course. Students should understand that ionic compounds are composed of cations and anions. Students should be able to define cation and anion; these may be new terms to Chemistry 2202 students as they are not explicitly defined in Science 1206.

The properties of acids were also studied in Science 1206; however, acid naming and formula writing are new concepts. Students should apply the following standard acid rules to name an acid given its formula or write the chemical formula given its name:

Ionic Name	Acid Name	Example
hydrogen __ide	hydro__ic acid	$HCl(aq) \rightarrow$ hydrochloric acid
hydrogen __ate	__ic acid	$H_2SO_4(aq) \rightarrow$ sulfuric acid
hydrogen __ite	__ous acid	$HNO_2(aq) \rightarrow$ nitrous acid

These rules may be provided for instructional purposes; however, students should know and be able to apply during assessments.

The discussion of acids does not need to include organic acids such as acetic acid or benzoic acid. These will be addressed in the Organic Chemistry unit.

For elaboration on SCO 14.0, refer to the Integrated Skills unit.

Continued

Classifying Compounds

Sample Teaching and Assessment Strategies

Activation

Students may

- Brainstorm the rules for naming all types of ionic compounds (i.e., contain simple ions, multivalent ions, hydrates, and polyatomic ions).
- Participate in a student-as-teacher activity. Questions and answers are provided by the teacher (or are student prepared) and relate to prior knowledge of naming compounds. Work with a partner; one will ask a question and provide feedback to another's response.

Connection

Teachers may

- Share samples of materials that contain chemicals for which students have previously written formulas and names. For example, boric acid is a component of several contact lens solutions.

Students may

- Create a list of household chemicals. Name the significant chemical in each.
- Use flashcards which contain ion names. Combine flashcards to make the name of a complete ionic compound. Practice writing the formula associated with that compound.

Consolidation

Students may

- Use a periodic table to predict the formation of molecular and ionic compounds. Name the compounds.
- Develop a flow-chart or concept map to summarize the naming system studied.
- Research and discuss other naming systems in chemistry (e.g., organic nomenclature).
- Use flashcards which contain molecular prefixes and non-metal atoms to make the name of a complete molecular compound. Write the formula.
- Create a Jeopardy game of chemical nomenclature using flashcards. Include rules, names, and formulas.

Continued

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (Teacher Resource [TR])

- pp. 17-26, 89, 107

Chemistry: Newfoundland and Labrador (Student Resource [SR])

- pp. 17-22, 31-42

Newfoundland and Labrador Teacher Resource & Solutions Manual (Digital)

Suggested

Resource Links: <https://bit.ly/2q0GY06>

- Chemical Naming
- Molecular Naming
- Wolfram Alpha: Chemistry Solutions

Classifying Compounds

Outcomes

Students will be expected to

26.0 write and name the formulas of ionic and molecular compounds, following simple IUPAC rules
[GCO 3]

14.0 describe and apply classification systems and nomenclatures used in the science
[GCO 2]

Focus for Learning

Sample Performance Indicator

Complete the table below. Provide the proper IUPAC name, or write the chemical formula and identify the type of substance.

Chemical Name	Chemical Formula	Ionic, Molecular, Acid, or Metal
sodium nitrate		
	BaCl ₂	
ammonium bromide		
	H ₂ SO ₄ (aq)	
lead(IV) borate		
	NO ₂	
hydroiodic acid		
	NiPO ₄	
gold		
	HClO	
copper(II) chloride dihydrate		
	Ni(NO ₃) ₃ • 9H ₂ O	

Classifying Compounds

Sample Teaching and Assessment Strategies**Extension**

Students may

- Research and present (e.g., oral presentation, poster) chemical naming systems before IUPAC and discuss the effects of IUPAC on the scientific community.

Resources and Notes**Authorized**

Chemistry: Newfoundland and Labrador (TR)

- pp. 17-26, 89, 107

Chemistry: Newfoundland and Labrador (SR)

- pp. 17-22, 31-42

Newfoundland and Labrador Teacher Resource & Solutions Manual (Digital)

The Mole

Outcomes

Students will be expected to

27.0 define molar mass and perform mole-mass inter-conversions for pure substances
[GCO 3]

28.0 explain the roles of evidence, theories, and paradigms in the development of scientific knowledge
[GCO 1]

Focus for Learning

Students should define the mole as the number of

- particles denoted by Avogadro's number 6.02×10^{23} , and
- atoms in exactly 12 g of carbon-12.

Students should discuss the mole and molar mass in terms of isotopes, isotope notation (e.g., $^{35}_{17}\text{Cl}$), and isotope names (e.g., chlorine-35). They are not required to calculate the average atomic mass of an element using percent abundances, but to recognize that the periodic table provides the weighted average of all naturally occurring isotopes (atomic molar mass). Students should explain why the average atomic mass of C is 12.01 u and not 12 u. For example,

Isotope	Atomic Mass (u)	Percent Abundance (%)	Mass (u)
Carbon -12	12	98.9	11.87
Carbon -13	13	1.1	0.14
Carbon -14	14	0.0001	0.00014
		Average Atomic Mass	12.01

Teachers should state that the molar mass is the same as the average atomic mass, except in g/mol. Students should calculate or determine the molar mass of elements and compounds and understand STP and the molar volume of a gas at STP. STP conditions have been redefined (IUPAC) as 0.00 °C and 100 kPa; therefore, the molar volume of gas should be 22.7 L/mol. Students should also apply mole conversions using unit conversions (dimensional analysis) or appropriate formulas. It is good practice for students to include correct units within each calculation (i.e., keeping units with all numbers during a calculation) and not only at the end of the calculation. Conversions should include those between

- mass and moles for elements and compounds ($n = \frac{m}{M}$);
- atoms and moles for pure monoatomic elements;
- molecules and moles for molecular compounds;
- formula units and moles for ionic compounds;
- gas volume and moles under STP conditions ($n = \frac{V}{V_{STP}}$);
- particles (atoms, molecules, or formula units) and mass;
- particles and gas volume; and
- gas volume and mass.

Students are not expected to convert between atoms and molecules, or formula units and ions. To convert from particles to moles, students may use a version of ($n = \frac{N}{N_A}$), where N represents the number of particles and N_A is Avogadro's number, 6.02×10^{23} particles/mol.

Emphasis should be placed on correct use of units and significant figures. In Science 1206, students demonstrated use of units and significant figures related to numerical calculations. In Chemistry 2202, they should apply the significant figure rules (Appendix A). While problem solving and conversions are the main focus, consideration for communicating scientific information through the use of units and significant figures should also be included.

Continued

The Mole

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Review the rules of significant figures.
- Ask: What contributes to the mass of an atom? Which subatomic particle identifies an element? (Science 9)
- Discuss: Although cm^3 is technically accurate, litres is arguably more useful in most applications dealing with liquids and gases.

Students may

- Identify elements that have close to whole number molar mass values (e.g., fluorine, molar mass 19.00 g/mol) and predict why.
- Share ways to communicate quantities (e.g., bytes, cord of wood).
- Brainstorm and discuss examples where scientific understanding was revised as a result of a technological invention.
- Participate in a group self-discovery of molar mass calculations: Form five groups. Use different chemicals to determine how the molar mass on the bottle is determined, given the formula.
 - Group 1: a simple metal (Zn)
 - Group 2: a simple binary compound (NaCl)
 - Group 3: a more complex compound (MgSO_4)
 - Group 4: a compound with higher complexity ($\text{Al}_2(\text{SO}_4)_3$)
 - Group 5: a hydrated compound ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$)

Present solutions in sequence with complexity.

Connection

Teachers may

- Use analogies to describe Avogadro's number (e.g., water flows over Niagara Falls at about 650 000 kL/min; calculate the number of years it would take for one mole of water drops to flow over; calculate the distance a mole of paper clips could reach).
- Provide students with the relative abundance of various isotopes and ask them to compare the average atomic mass of the element. For example, chlorine-35 and chlorine-37 have a relative abundance of 75.58% and 24.22% respectively. The average atomic mass is 35.45 g/mol. What do they notice?

Students may

- Predict which isotope is most abundant in nature based on the average atomic mass. Research the abundances to test predictions. See below for an example:

Element Isotopes	Average Molar Mass (g/mol)
lithium-6 and lithium-7	6.941
uranium-235 and uranium-238	238.028

Continued

Resources and Notes

Authorized

Appendices

- Appendix A: Scientific Conventions

Chemistry: Newfoundland and Labrador (TR)

- pp. 19-23, 28-37, 70-71, 89, 107

Chemistry: Newfoundland and Labrador (SR)

- pp. 23-26, 56-71, 72-75

Suggested

Resource Links: <https://bit.ly/2q0GY06>

- Moles: Avogadro's Number
- Experimental Design and Scientific Method
- Isotopes

Note

- Scientific Notation is not included in mathematics curriculum.

The Mole

Outcomes

Students will be expected to

- 7.0 use instruments effectively and accurately for collecting data
[GCO 2]
- 12.0 select and use apparatus and materials safely
[GCO 2]
- 13.0 demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials
[GCO 2]
- 20.0 explain how data support or refute the hypothesis or prediction
[GCO 2]
- 21.0 identify and correct practical problems in the way a technological device or system functions
[GCO 2]
- 29.0 explain how a major scientific milestone revolutionized thinking in the scientific communities
[GCO 1]
- 30.0 analyze and describe examples where scientific understanding was enhanced or revised as a result of the invention of a technology
[GCO 1]

Focus for Learning

Students should complete a lab investigation that includes converting moles of common chemicals/elements to mass or create a display of one mole of a substance. Teachers should introduce weighing methods including weighing by difference and weighing by taring the balance. Teachers should provide samples of various chemicals (e.g., NaCl, Al, H₂O).



Students should follow the steps below:

1. Given one mole samples of each substance, predict which substance will have the greatest mass.
2. Calculate the mass of one mole of each substance.
3. Choose an appropriate weighing technique (i.e., taring or weight by difference) to determine the actual mass of each sample.
4. Compare predicted to actual mass.

Students should discuss the importance of the mole concept and how it changed chemistry (i.e., provided a method of quantifying chemistry, allowing chemists to make accurate predictions using balanced chemical equations, therefore impacting production of chemicals).

Students should also analyze situations where scientific understanding has been enhanced as a result of technology (e.g., acceptable levels of food additives, athlete testing for banned drugs).

For elaboration on outcomes 7.0, 12.0, 13.0, 20.0, and 21.0, refer to the Integrated Skills unit. Teachers may also wish to address and assess additional skill outcomes (e.g., SCOs 8, 19).

Attitude

Encourage students to value the contributions to scientific and technological developments made by people from many societies and cultural backgrounds. [GCO 4]

Sample Performance Indicator

Calculate the following:

1. The number of formula units in 0.25 mol of magnesium bromide
2. The mass of 0.875 mol of gold
3. The volume occupied by 11.9 mol of sulfur dioxide at STP
4. The number of formula units in 3.45 g of calcium chloride
5. The volume of H₂ if there are 4.710 g of H₂
6. The number of molecules in 5.00 L of carbon dioxide at STP

The Mole

Sample Teaching and Assessment Strategies

Students may (continued)

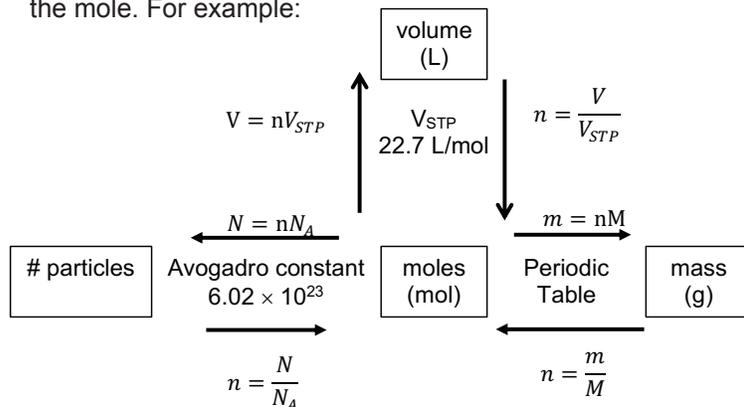
- Find and share analogies of the magnitude of the mole.
- Show they understand the magnitude of Avogadro's number by counting objects (e.g., sample of dry beans) and converting the number to a mole amount for that sample.
- Develop and participate in Mole Day activities (e.g., students calculate the number of moles of carbon in one pencil lead).
- Discuss examples of how we can now 'see' things that could only be theorized before the development of technology (e.g., gas spectrometry, mass spectrometry, infrared spectrometry, X-ray crystallography, NMR, MRI, X-ray, CAT scan, ultrasound).
- Show understanding that atoms of the same element have different numbers of neutrons, thus different mass numbers.

Isotope Name	Isotope Symbol	Mass Number	Protons	Neutrons
carbon-12				
		13	6	
			6	8

Consolidation

Students may

- Observe a balloon filled with an unknown elemental gas. Develop a method to determine the identity of the gas, recognizing that elements can be distinguished by their molar mass.
- Research and present results on a major scientific milestone that revolutionized scientific thinking.
- Develop a concept map to link possible conversions to and from the mole. For example:



Extension

Students may

- Find the atomic masses and percent abundances for stable isotopes of different elements and calculate their atomic mass. Compare the calculated value to the value on the periodic table.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 23, 31, 28-37

Chemistry: Newfoundland and Labrador (SR)

- pp. 48-81
- p. 70 (Investigation)

Note

The magnifying glass icon is used to denote required investigations of questions, ideas, problems, and issues.



Solubility and Solutions

Outcomes

Students will be expected to

31.0 explain solubility, using the concept of equilibrium [GCO 3]

32.0 define the concept of equilibrium as it pertains to solutions [GCO 3]

33.0 explain the variations in the solubility of various pure substances, given the same solvent [GCO 3]

35.0 analyze society's influence on scientific and technological endeavours [GCO 1]

Focus for Learning

In Science 7, students were introduced to solutions. Students should be familiar with terms such as solute, solvent, dilute, concentrated, unsaturated, and saturated. Although students in Science 7 may have prepared crystals from supersaturated solutions, they were not introduced to the term supersaturated. In Chemistry 2202, teachers should discuss examples of solutions. These include

- alloys such as brass, sterling silver, and steel; and
- aqueous solutions and gases such as air.

Students should be able to distinguish among solutions that are unsaturated, saturated, supersaturated, miscible, and immiscible as well as those that are dilute and concentrated. They should understand the dynamic equilibrium present in a saturated solution (i.e., a physical dynamic equilibrium between two physical processes; dissolving-recrystallization). The concept of equilibrium will be addressed further in Chemistry 3202.

Students should recognize that the degree of solubility depends on both the solute and the solvent. Solubility is temperature/pressure dependent. An increase in temperature increases the solubility of some solutes, such as table salt in water, but decreases the solubility of other solutes, such as oxygen in water. Students are not expected to explain variations at this point (33.0). This will be addressed in Unit 2.

A societal connection relating to solubility and the environment should be made at this point. For example, teachers might discuss why high solubility of pesticides in water is considered high risk for groundwater contamination. This has ignited a movement to regulate the chemical characteristics of modern day pesticides.

Students should be able to define concentration in terms of molarity (moles per litre of solution) and should also be introduced to the concentration formula ($c = \frac{n}{V}$).

Students should be able to calculate

- the amount concentration of a solution, given the moles or mass of the solute and the volume of solution;
- the moles or mass of the solute dissolved, given the amount concentration and the volume; and
- the volume of solution, given the moles or mass of the solute and amount concentration.

Elaboration on the concept of dilution of a solution should include the derivation of the formula ($c_i V_i = c_f V_f$). Students should understand that when a solution is diluted by adding a solvent, the initial number of moles of solute are equal to the final number of moles of solute. They should be able to calculate any unknown concentration or volume before or after the dilution.

Continued

Solubility and Solutions

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Discuss solution terms: solute, solvent, dilute, concentrated, unsaturated, saturated, and supersaturated. Prepare coloured solutions of the same solute (e.g., CuCl_2 , NiCl_2 or Kool-Aid™) to help students visualize the various degrees of concentration, from dilute to concentrated (final solution will be saturated with solid remaining at the bottom of the flask). Note: Teachers should consider safety and disposal issues when selecting a solute.
- Demonstrate the solubility of various substances with the same solvent (e.g., salt vs. sugar in water).

Students may

- Discuss their understanding of a solution using the terms solute and solvent. Provide examples of solutions (e.g., solids in water which will lead to the definition of aqueous solution; this may have been defined in Science 1206). Answer the following questions:
 - Does the solvent have to be water?
 - Does the solute have to be solid?
 - Provide alternate examples (e.g., brass, sterling silver, steel, and air).
- Identify examples of unsaturated and saturated solutions.
- Recall and discuss (from Science 7) the growing of crystals in solutions.
- Given a solution, identify the solute and solvent.
- Participate in an activity which identifies that a solution has been diluted based on a change in colour intensity.

Connection

Teachers may

- Demonstrate a commercial application of supersaturated solutions using sodium acetate hand warmers. Online videos will also demonstrate supersaturated solutions.

Students may

- List various food products from concentrate and discuss the methods and motivation behind their use (e.g., apple juice, honey, clothes detergents, and cleaning solvents).
- Discuss why many concentrated substances need to be diluted prior to use (e.g., cleaning solvents).
- Develop a poster that identifies several pesticides, their properties, including water solubility, and potential effects on the environment.

Continued

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 34, 39-47

Chemistry: Newfoundland and Labrador (SR)

- pp. 84-107

Suggested

Resource Links: <https://bit.ly/2q0GY06>

- Concentration and Dilution
- Saturated, Unsaturated, and Supersaturated Solutions (video)
- Saturated, Unsaturated, and Supersaturated Solutions (video tutorial)
- Brightstorm: Types of Solutions (video)

Solubility and Solutions

Outcomes

Students will be expected to

7.0 use instruments effectively and accurately for collecting data
[GCO 2]

8.0 estimate quantities
[GCO 2]

12.0 select and use apparatus and materials safely
[GCO 2]

13.0 demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials
[GCO 2]

35.0 analyze society's influence on scientific and technological endeavours
[GCO 1]

Focus for Learning

Students should complete a lab investigation where they prepare a standard solution of a precise concentration. Proper standard solution preparation from a solid should follow specific steps:



1. Calculate the mass of solute needed.
2. Collect the mass of solute using a weighing boat or small beaker (e.g., 100 mL), scale, and scoopula.
3. Transfer mass of solute (using a funnel) into a volumetric flask and add a small amount of solvent; swirl to dissolve. Alternately, dissolve the solute in the small beaker in approximately 60 mL of solvent (estimate). Then, using a funnel, transfer the solution to a volumetric flask.
4. Add solvent (using a wash bottle) until the meniscus rests on the calibration (etched) line.
5. Stopper the flask and mix several times by inversion.

Students should also be able to follow a series of steps such as those listed below to perform a standard dilution from a standard solution:

1. Collect a precise volume using a volumetric pipette and ensure the meniscus rests on the calibration (etched) line.
2. Deliver to a volumetric flask.
3. Add solvent (using a wash bottle) until the meniscus rests on the calibration (etched) line.

Students should analyze situations where change occurs as a result of societal influences as it relates to negative effects of certain solutions (e.g., phosphate ban in detergents, steroid use in sports, ozone depletion, water contamination by industry).

For elaboration on outcomes 7.0, 8.0, 12.0, and 13.0, refer to the Integrated Skills unit.

Attitude

Encourage students to

- project the personal, social, and environmental consequences of proposed action; and
- want to take action for maintaining a sustainable environment.
[GCO 4].

Sample Performance Indicator

Complete the following:

1. Prepare a 100.0 mL solution of sucrose $C_{12}H_{22}O_{11}$ (e.g., Kool-Aid™ crystals) with a concentration of 0.100 mol/L.
2. Dilute the prepared solution of sucrose $C_{12}H_{22}O_{11}$ (e.g., Kool-Aid™ crystals) to a concentration of 0.0100 mol/L.

Solubility and Solutions

Sample Teaching and Assessment Strategies

Consolidation

Students may

- Create a video or other visual product outlining the steps required to prepare a standard solution from a solid to a specific concentration (or dilution technique).
- Demonstrate proper standard solution preparation from a solid. Common techniques and apparatus for solution preparation are listed in column 2.
- Demonstrate proper standard solution preparation by dilution. Emphasis should be placed on calculating the required concentration or volume, on technique, and on evidence of dilution.
- Determine the molar solubility of various solutes in a variety of solvents from student-derived data.
- Determine three potential sources of error if good technique is not followed.

Extension

Students may

- Propose a technique to increase the concentration of a stock solution without adding more compound (distillation/evaporation of solvent to reduce solvent).
- Propose techniques to change a saturated solution to an unsaturated solution (i.e., add solvent and increase temperature).
- Provide three reasons why a volumetric flask is the most appropriate apparatus for creating a precisely concentrated solution.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 39-47

Chemistry: Newfoundland and Labrador (SR)

- pp. 103-107 (Investigation)

Chemical Reactions

Outcomes

Students will be expected to

36.0 use the solubility generalizations to predict the formation of precipitates [GCO 3]

Focus for Learning

Students have an understanding (Science 1206) of conservation of mass and balancing chemical equations given reactants and products; they balanced equations for five reaction types. Chemistry 2202 students should predict products and identify states of all chemicals in the reaction. Generally, ionic compounds that are reactants are aqueous solutions yet the states of ionic compounds produced are determined using rules from the solubility table.

Solubility Rules for Ionic Compounds in Water at 25°C.

Ions	Group 1 NH ₄ ⁺ H ⁺ (H ₃ O ⁺)	ClO ₃ ⁻ NO ₃ ⁻ ClO ₄ ⁻	Cl ⁻ Br ⁻ I ⁻	CH ₃ COO ⁻	SO ₄ ²⁻	S ²⁻	OH ⁻	PO ₄ ³⁻ SO ₃ ²⁻ CO ₃ ²⁻
(aq) high Solubility (> 0.1 mol/L)	all	all	most	most	most	Group 1 Group 2 NH ₄ ⁺	Group 1 NH ₄ ⁺ , Sr ²⁺ Ba ²⁺ , Tl ⁺	Group 1 NH ₄ ⁺
(s) low Solubility (< 0.1 mol/L)	none	none	Ag ⁺ , Tl ⁺ Hg ₂ ²⁺ , Hg ²⁺ Cu ⁺ , Pb ²⁺	Ag ⁺ Hg ₂ ²⁺	Ca ²⁺ , Sr ²⁺ Ba ²⁺ , Ra ²⁺ Pb ²⁺ , Ag ⁺	most	most	most

Reaction types are listed below:

- Simple Formation – two elements produce a single compound
- Simple Decomposition – a single compound produces elements of which it is composed
- Single Replacement – an element and a compound produces a new element and a new compound
- Double Replacement – two ionic compounds produces two new ionic compounds; an acid and a base produces a salt and water
- Combustion – should be limited to the complete combustion of hydrocarbons (C_xH_y); hydrocarbon and oxygen produce carbon dioxide gas and water vapour

For single replacement reactions involving a metal that can produce more than one cation (multivalent), the ion to be used is the one most commonly occurring (top on periodic table for that metal). Students are not expected to make predictions based on the activity series.

Students should write dissociation equations to show that aqueous ionic compounds exist as ions in aqueous solutions. They should use mole ratios from a dissociation equation to calculate the concentration of an ion in a solution. Students should also write total and net ionic equations for single and double replacement reactions. Limit to ionic compound dissociations; Chemistry 3202 includes strong/weak acids.

Sample Performance Indicator

Write a balanced chemical equation by predicting the products:

1. Combustion of propane (C₃H₈)
2. Decomposition of iron(III) oxide
3. Reaction of aqueous sodium carbonate and aqueous calcium nitrate; write the total and net ionic equations
4. Reaction of magnesium with copper(II) sulfate; write the total and net ionic equations

Chemical Reactions

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Facilitate a discussion to determine students' prior knowledge of the types of reactions studied in Science 1206 (simple formation, simple decomposition, single replacement, double replacement, and combustion).

Students may

- List and explain the five reaction types studied in Science 1206.
- Provide evidence of a chemical reaction.
- Participate in a sharing activity. With a partner, list the five reaction types, discuss distinguishing characteristics, and share discussion points with the class.

Connection

Students may

- Identify the precipitate when given the double replacement reaction.
- Record products with correct states of matter in a table or chart (with reactants provided).
- Hypothesize how to predict products for different types of reactions when given three balanced equations for one type and asked to predict the fourth. For example, given
 - $2 \text{KI} + \text{Pb}(\text{NO}_3)_2 \longrightarrow \text{PbI}_2 + 2 \text{KNO}_3$
 - $\text{Na}_2\text{SO}_4 + \text{CaCl}_2 \longrightarrow \text{CaSO}_4 + 2 \text{NaCl}$
 - $2 \text{Li}_3\text{PO}_4 + 3 \text{Ba}(\text{OH})_2 \longrightarrow \text{Ba}_3(\text{PO}_4)_2 + 6 \text{LiOH}$
 Predict: $\text{Na}_2\text{CO}_3 + \text{Cu}(\text{ClO}_3)_2 \longrightarrow ??$

Consolidation

Students may

- Complete a lab investigation that involves working with a set of solutions. Combine small chemical quantities of aqueous solutions of ionic compounds. Observe which combinations react to produce a precipitate (insoluble product).
- Write a balanced chemical equation by predicting the products for
 - reaction of magnesium metal with oxygen, and
 - reaction of bromine with potassium iodide.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 23, 29, 41-43, 49-61, 64-71, 107

Chemistry: Newfoundland and Labrador (SR)

- pp. 114-136

Suggested

Resource Links: <https://bit.ly/2q0GY06>

- Balancing Equations
- The Six Reaction Types

Chemical Reactions

Outcomes

Students will be expected to

- 3.0 state a prediction and a hypothesis based on available evidence and background information [GCO 2]
- 5.0 develop appropriate sampling procedures [GCO 2]
- 6.0 implement appropriate sampling procedures [GCO 2]

Focus for Learning

Students should complete a lab investigation that focuses on predicting products. They should implement sampling procedures appropriately as well as perform and identify different reaction types.



Students should perform a stations activity in the lab where they predict the products and demonstrate each of the five reaction types:

1. Simple formation (e.g., burn a piece of steel wool [iron] or a piece of magnesium ribbon with oxygen); note: teachers may choose to complete this as a demonstration as there are safety issues associated with burning substances (i.e., burning magnesium produces a bright light that should not be observed directly)
2. Simple decomposition (e.g., electrolysis of water or decomposition of hydrogen peroxide in the presence of a catalyst such as magnesium dioxide or sodium iodide)
3. Combustion (e.g., burn a candle or light an ethanol burner)
4. Single replacement (e.g., magnesium with hydrochloric acid, zinc with copper(II) sulfate, or copper with silver nitrate)
5. Double replacement (e.g., iron(III) nitrate and sodium hydroxide, hydrochloric acid with a few drops of phenolphthalein and sodium hydroxide, or calcium chloride and sodium carbonate)

Students can test for some of the products of these reactions (e.g., O_2 , CO_2 , H_2 , H_2O).

Caution: When performing demonstrations and lab activities that utilize acids and bases, teachers should be aware that they are both corrosive to human tissue and can be very reactive.

When diluting an acid with water, it is very important to always add the acid to the water and not the other way around. After calculating the correct amount of water needed to dilute the acid to the desired pH level, use a flask of cooled, distilled water and add the acid to the water in small doses. Also, it is important to wear a lab coat, goggles and gloves, and if possible, perform the dilution in a fume hood, so that the fumes will not be inhaled.

For elaboration on outcomes 3.0, 5.0, and 6.0, refer to the Integrated Skills unit. Teachers may also wish to address and assess additional skill outcomes (e.g., SCOs 7.0, 8.0, 13.0).

Attitude

Encourage students to

- show concern for safety and accept the need for rules and regulations; and
- value the processes for drawing conclusions. [GCO 4]

Chemical Reactions

Sample Teaching and Assessment Strategies**Consolidation**

Students may

- Predict possible reactants given the products of a reaction.
- Predict possible products given the reactants of a reaction.
- Predict the state of matter of products (if ionic, use solubility table).
- Create a balanced chemical equation (including states) given the reactants in word form.
- Answer: Given a reaction completed in a lab activity, predict what would happen if a different reactant (with one atom/ion changed) were used. Balance the new chemical equation.

Resources and Notes**Authorized**

Chemistry: Newfoundland and Labrador (TR)

- pp. 49-61

Stoichiometry

Outcomes

Students will be expected to

37.0 identify mole ratios of reactants and products from balanced chemical equations
[GCO 3]

38.0 perform stoichiometric calculations related to chemical equations
[GCO 3]

Focus for Learning

Students should be able to define mole ratio and use a balanced chemical equation to identify and write a mole ratio between any two chemicals in a balanced reaction.

To aid in the discussion of mole ratio, teachers may discuss how mole ratios in chemical processes relate to ratios used in real life applications (e.g., ratio of fertilizer components, ratio of fuel to oxygen in rocket lift, ratios of cake ingredients).

Students should perform stoichiometric problems involving

- mole-to-mole stoichiometry,
- gravimetric stoichiometry,
- solution stoichiometry,
- gas stoichiometry, and
- any combination of the above (e.g., using mass of one substance to determine the volume of gas of another substance at STP).

A general guideline for performing stoichiometric calculations involves

- calculating the moles of a substance given (if not given moles),
- predicting moles of unknown substance using a mole ratio,
- using the predicted moles to calculate the amount of unknown substance (depending on which variable the problem is asking to calculate), and
- calculating the concentration of an ion in a solution.

Students should understand that a chemical equation is read in terms of moles and not mass and that when both reactants are completely consumed in a reaction, mass is conserved.

They should understand both limiting reagent (reactant that is completely consumed in a reaction) and excess reagent (reactant that remains after a reaction is complete).

Students should study one method of determining limiting and excess reagents. They will then use the limiting reagent to determine the amount of product produced. For example, students may calculate the amount of product from each reactant; the limiting reagent will produce the least amount of product.

Students are not expected to calculate the amount of excess reactant which remains in a limiting reactant calculation.

Continued

Stoichiometry

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Introduce the concept of mole ratios using familiar analogies such as those listed below:
 - If you have two cars, how many tires are there?
 - If you have three cars, how many tires are there?
 - What is the ratio of cars to tires?
- Use familiar limiting analogies. For example, given the recipe: 2 slices of bread + 1 ham slice → 1 sandwich, how many sandwiches can be made if we have 10 slices of bread and 7 slices of ham?
- Provide examples which will allow students to identify the limiting and excess reagent without calculations (e.g., using the sandwich analogy or whole numbers of moles in a reaction).

Students may

- Write all the ratios for the chemical decomposition of water:
 $2 \text{H}_2\text{O}(\text{l}) \rightarrow 2 \text{H}_2(\text{g}) + \text{O}_2(\text{g})$.
- Explain how their grade on a test is similar to how percentage yield is derived from actual and theoretical yield in the lab.
- Participate in a demonstration activity, “Are you the limiting reactant?”
 1. Place baking soda (6 g, 12 g, 18 g, 24 g, 30 g, and 36 g) into six balloons which are attached to 2L plastic bottles, each containing 250 mL of vinegar.
 2. Flip balloons up and record observations (i.e., size of balloons and amount of solid remaining in bottom of bottle). Rank in size on a scale of 1-6.
 3. Analyze observations and identify the limiting reagent in each bottle. Explain.
- Collaborate to list and share authentic or real life examples of limiting and excess reagents.

Connection

Teachers may

- Introduce a specific chemical reaction and analyze the changes in moles when compared to the masses of the reactants and products.

	2 NaN ₃	→	2 Na	+	3 N ₂
Mass	130.04 g		45.98 g		84.06 g
Moles	2		2		3

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 31, 34, 43, 50-51, 63-76

Chemistry: Newfoundland and Labrador (SR)

- pp. 156-175, 180-189

Teaching and Learning Strategies: <https://bit.ly/2lrDSJl>

- Limiting Reagents

Continued

Stoichiometry

Outcomes

Students will be expected to

- 39.0 predict how the yield of a particular chemical process can be maximized [GCO 3]

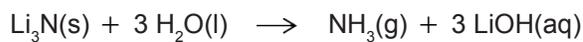
Focus for Learning

Students should have a clear understanding of actual yield, theoretical yield, and percentage yield. They should perform calculations involving theoretical and percentage yield based upon the limiting reactant calculations described above. Students should also understand the reasons for differences between actual yield, and theoretical yield. They should be able to predict ways to maximize their actual yield by considering sources of error and equipment chosen, which may include

- impurities,
- incomplete reactions (connect to rates in Science 1206),
- inaccuracy of the scale used, and
- technique (loss of product).

Sample Performance Indicators

1. In the reaction below, 4.87 g of lithium nitride reacts with 5.80 g of water to produce ammonia gas and lithium hydroxide. Determine the limiting and excess reagents and give a reason for your choices.



2. Given the reaction below, what is the percent yield of CaO if 24.8 g of CaCO_3 is heated and 13.1 g of CaO is recovered?



Stoichiometry

Sample Teaching and Assessment Strategies

Students may

- Discuss how chemical reactions have a limiting reagent and how the yield is affected by the limiting reagent.
- Revisit previous reactions completed (to introduce the reaction types) and predict the mass of product expected. Explore mass relationships, mole ratios, and percent yields.
- Explain the importance of a balanced chemical equation in performing stoichiometric calculations.
- List and discuss common examples of stoichiometry from their own lives (e.g., cooking recipes, mixing cement, 'mixed' gasoline).
- Propose reasons (economics, availability, toxicity, etc.) why certain chemicals must be limiting in various chemical applications.

Consolidation

Students may

- Complete exit cards to indicate the steps they would follow to complete a mass to mass stoichiometry problem.
- Develop a poster outlining the steps required to solve a stoichiometry problem.
- Create a skit, poem, or song to explain the difference between limiting and excess reagents.
- Create one or more stoichiometry problems. Circulate the problems throughout the class for others to solve.
- Develop a Powerpoint™, Prezi™, comic, or poster of a technology that uses ratios in its production or function (e.g., petroleum refining, production of ammonia, burning of fuels).
- Research and write a report on a product that involves the use of stoichiometry and limiting and excess reactants. Examples include
 - a consumer product such as hair colouring,
 - a household cleaning solution,
 - a specific type of pesticide used in home gardens, and/or
 - an over-the-counter medication.

Extension

Students may

- Calculate the amount of excess reagent remaining or conversely the amount of extra limiting reagent required for a stoichiometric equivalence.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 50, 63-76

Chemistry: Newfoundland and Labrador (SR)

- pp. 176-179

Stoichiometry

Outcomes

Students will be expected to

- 2.0 design an experiment identifying and controlling major variables [GCO 2]
- 9.0 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data [GCO 2]
- 17.0 identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty [GCO 2]
- 19.0 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion [GCO 2]
- 22.0 communicate questions, ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others [GCO 2]

Focus for Learning

Students should work in small groups to design and carry out a lab investigation dealing with percentage yield and develop filtration skills. The design and investigation should include the following steps:



1. Describe how to carry out the filtration of a precipitate.
2. Appropriately select materials and use safely.
3. Perform the filtration of a precipitate.
4. Complete calculations of theoretical yield and percent yield.
5. Identify safety concerns with this laboratory activity and list precautions taken.
6. Identify sources of error.

In their design, students may use solutions of two ionic compounds that will react to produce one precipitate. The precipitate should be collected through filtration and dried for subsequent weighing.

As a general guide, teachers can look for the following steps to be followed when students design and carry out the above investigation:

1. Weigh samples.
2. Set up a filtration apparatus.
3. Fold a filter paper, record its mass, and place in the funnel.
4. Decant the reaction mixture into the filter paper.
5. Rinse the beaker and filter paper.
6. Remove the filter paper with contents and dry overnight.
7. Record the mass of filter paper + precipitate.
8. Find the limiting reagent, the theoretical yield of precipitate, and the percent yield.
9. Discuss sources of error.

Students should use mass data to calculate percent yield and apply interpretation of their results to list possible sources of error.

For elaboration on outcomes 2.0, 9.0, 17.0, 19.0 and 22.0, refer to the Integrated Skills unit. Teachers may also wish to address and assess additional skill outcomes (e.g., SCOs 7.0, 12.0).

Sample Performance Indicator

Predict what would probably happen to get a % yield greater or less than 100%. Design an experiment to test this.

Stoichiometry

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Discuss steps and procedures necessary when designing an experiment.
- Share videos outlining effective use of laboratory materials. Discuss consequences of not using materials appropriately.

Students may

- Share previous laboratory experiences regarding safety and use of materials.

Connection

Students may

- Find an online sample of an experiment that has been designed by students. Make notes to list strengths and weaknesses of the design. Discuss.
- Create a poster or other visual representation to depict correct use of and/or proper disposal of laboratory materials.
- View a video of an activity such as the reaction of solutions of potassium iodide and lead(II) nitrate. Write a balanced chemical equation to predict the products. Use the volume and concentrate data: 100.0 mL of 0.100 mol/L potassium iodide, 75.0 mL of 0.150 mol/L lead(II) nitrate, to
 - identify the limiting reagent,
 - calculate the theoretical yield of precipitate, and
 - determine the percent yield if the actual yield of PbI(s) is 1.98 g.

Consolidation

Students may

- Design an experiment to identify the limiting species in chemical reactions. Make a connection between chemistry and industry.
- Design an experiment and then present an oral report which outlines the process of creating and carrying out the experiment. Facilitate discussion and answer questions.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 63-76, 107

Chemistry: Newfoundland and Labrador (SR)

- pp. 190-193 (Investigation)

Applications of Stoichiometry

Outcomes

Students will be expected to

40.0 identify various stoichiometric applications [GCO 3]

21.0 identify and correct practical problems in the way a technological device or system functions [GCO 2]

34.0 compare processes used in science with those used in technology [GCO 1]

41.0 identify various constraints that results in trade-offs during the development and improvement of technologies [GCO 1]

42.0 identify and describe science-and technology-based careers related to the science they are studying [GCO 1]

Focus for Learning

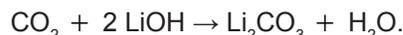
Students should engage in research and analysis of modern technologies (products and processes), systems, and careers. Teachers should make connections to various authentic applications of stoichiometry, but emphasis should be placed on student engagement, research, and analysis.

Examples of stoichiometric calculations from recognizable applications include the following:

- Calculate the mass of sodium azide required to properly inflate an airbag with nitrogen:



- Calculate the amount of carbon dioxide able to be scrubbed from the atmosphere on the space station using lithium hydroxide:



- Mix paint colours to create secondary/tertiary colours (requires stoichiometry without realizing it). For example, a paint company may make the colour mulberry by using eggplant, rooster red, and magenta in a 3:2:1 ratio.
- Use Haber process for the production of ammonia.

Students should focus on commercial examples of chemical processes and discuss these reactions in terms of usefulness to society, technology trade-offs, and the intention of the producer of the products.

Students should examine examples of careers related to solutions and stoichiometry. Examples are listed below:

Anaesthesiologist	Chemical Engineer	Farmer
Biochemist	Dentist	Food Safety Inspector
Chef	Environmental Chemist	Pharmacist

For elaboration on outcome 21.0, refer to the Integrated Skills unit.

Attitude

Encourage students to

- consider further studies and careers in science and technology related fields, and
- want to take action for maintaining a sustainable environment. [GCO 4]

Sample Performance Indicator

Research a current stoichiometry-related technology. Outline problems and propose alternatives. Some examples include alternatives to fossil fuel use, current and possible approaches to dealing with electronic wastes, industrial processes, and replacement of CFCs.

Applications of Stoichiometry

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Introduce how stoichiometry is used in the cooking industry (such as in doubling recipes when more product is desired).

Students may

- Create a given secondary colour from primary colour paints. Provide instruction to another student (using qualitative amounts) on how to recreate the same colour.

Connection

Teachers may

- Develop a problem based learning scenario involving stoichiometry and the community (e.g., municipal water treatment; chlorination and fluoridation).

Students may

- Identify different chemical reactions which produce the same product for an industrial application. Predict which would be best to use based on cost, availability of materials, environmental impact, product demand, etc.
- Select a career that is related to solutions and stoichiometry. Create a fictional curriculum vitae (CV) that would help this person secure a job.
- Identify local examples of industry that use chemical processes (e.g., Long Harbour, Iron Ore Company, Voisey's Bay, Come by Chance).

Consolidation

Students may

- Conduct research on an industrial process involving stoichiometry and determine how yield can be maximized. Research results can be communicated by presentation, poster, Powerpoint™, etc.
- Respond to a case study on or conduct research and report on a current issue. Suggestions include
 - current steps taken by the Canadian government to address climate change (carbon tax/trading);
 - industrial placement of carbon monoxide detectors, considering similar density to air;
 - retail cost of pharmaceuticals compared to production cost; and
 - retail response to BPA in plastic drinking containers.
- Select a career or profession that applies stoichiometry and solution chemistry better than the rest. Justify their choice in the form of a discussion or class debate.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 29, 63-76

Chemistry: Newfoundland and Labrador (SR)

- pp. 137-142

Suggested

Resource Links: <https://bit.ly/2q0GY06>

- Limiting Reagents and Theoretical Yield
- Filtration Lab Technique

Section Three:
Specific Curriculum Outcomes

Unit 2: From Structures to Properties

Strand Overview

Focus

All matter is held together by forces of attraction; one of the most important is chemical bonding. It is one of the key and basic concepts in chemistry since bonds are responsible for the physical and chemical properties of all substances. The different forces of attraction involved in matter and how it influences their properties is a focus of study in this unit.

Scientific inquiry is an important component of this unit. Students will use an inquiry based approach to identify and describe properties of ionic and molecular compounds as well as metallic substances. They will use common chemicals to differentiate among and classify substances as ionic, molecular, or metallic. Students will build chemical structures as well as investigate and compare strengths of intermolecular and intramolecular forces.

Emphasis is placed on the development of skills related to posing questions, making predictions, making and recording observations and measurements, analyzing and interpreting recorded data to identify emerging patterns, and communicating learning.

Outcomes Framework

GCO 1 (STSE): Students will develop an understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology.

- 61.0 analyze and describe examples where technologies were developed based on scientific understanding
- 62.0 analyze from a variety of perspectives the risks and benefits to society and the environment of applying scientific knowledge or introducing a particular technology
- 63.0 analyze examples of Canadian contributions to science and technology

GCO 2 (Skills): Students will develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions.

- 3.0 state a prediction and a hypothesis based on available evidence and background information
- 4.0 identify the theoretical basis of an investigation and develop a prediction and a hypothesis that are consistent with the theoretical basis
- 5.0 develop appropriate sampling procedures
- 10.0 use library and electronic research tools to collect information on a given topic
- 11.0 select and integrate information from various print and electronic sources or from several parts of the same source
- 15.0 identify limitations of a given classification system and identify alternative ways of classifying to accommodate anomalies
- 16.0 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots
- 23.0 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate idea, plans, and results

GCO 3 (Knowledge): Students will construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge.

- 33.0 explain the variations in the solubility of various pure substances, given the same solvent
- 43.0 illustrate and explain the formation of covalent bonds
- 44.0 explain the structural model of a molecular substance in terms of the various electron pairs that define it
- 45.0 illustrate and explain hydrogen bonds and van der Waals' forces
- 46.0 identify and describe the properties of molecular substances
- 47.0 describe how intermolecular forces account for the properties of molecular compounds
- 48.0 illustrate and explain the formation of ionic bonds
- 49.0 explain the structural model of an ionic substance in terms of the various bonds that define it
- 50.0 identify and describe the properties of ionic substances
- 51.0 describe how ionic bonding accounts for the properties of ionic compounds
- 52.0 relate the properties of a substance to its structural model of ionic compounds
- 53.0 illustrate and explain the formation of metallic bonds
- 54.0 identify and describe the properties of metallic substances
- 55.0 describe how metallic bonding accounts for the properties of metals
- 56.0 relate the properties of a substance to its structural model
- 57.0 describe the process of dissolving, using concepts of intramolecular and intermolecular forces
- 58.0 determine the molar solubility of a pure substance in water
- 59.0 explain the effect of solutes on the melting point of solid water, using intermolecular forces
- 60.0 classify ionic, molecular, and metallic substances according to their properties

GCO 4 (Attitude): Students will be encouraged to develop attitudes that support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society, and the environment.

Students are encouraged to:

- value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not
- show a continuing and more informed curiosity and interest in science and science-related issues
- acquire, with interest and confidence, additional science knowledge and skills, using a variety of resources and methods, including formal research
- confidently evaluate evidence and consider alternate perspectives, ideas, and explanations
- use factual information and rational explanations when analyzing and evaluating
- value the processes for drawing conclusions
- work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas
- be aware of the direct and indirect consequences of their actions

SCO Continuum

GCO 3: Knowledge		
Science 9 and Science 1206	Chemistry 2202	Chemistry 3202
<p>Science 9</p> <ul style="list-style-type: none"> identify examples of common elements and compare their characteristics and atomic structure describe changes in the properties of materials that result from some common chemical reactions investigate materials and describe them in terms of their physical properties <p>Science 1206</p> <ul style="list-style-type: none"> name and write formulas for some common ionic and molecular compounds, using the periodic table and a list of ions classify substances as acids, bases, or salts, based on their characteristics, name, and formula 	<ul style="list-style-type: none"> illustrate and explain the formation of covalent bonds explain the structural model of a molecular substance in terms of the various electron pairs that define it illustrate and explain hydrogen bonds and van der Waals' forces identify and describe the properties of molecular substances describe how intermolecular forces account for the properties of molecular compounds illustrate and explain the formation of ionic bonds explain the structural model of an ionic substance in terms of the various bonds that define it identify and describe the properties of ionic substances describe how ionic bonding accounts for the properties of ionic compounds relate the properties of a substance to its structural model of ionic compounds illustrate and explain the formation of metallic bonds identify and describe the properties of metallic substances describe how metallic bonding accounts for the properties of metals relate the properties of a substance to its structural model describe the process of dissolving, using concepts of intramolecular and intermolecular forces explain the variations in the solubility of various pure substances, given the same solvent determine the molar solubility of a pure substance in water explain the effect of solutes on the melting point of solid water, using intermolecular forces classify ionic, molecular, and metallic substances according to their properties 	<ul style="list-style-type: none"> describe various acid-base definitions up to and including the Brønsted-Lowry definition define the concept of dynamic equilibrium as it pertains to reversible chemical reactions explain temperature and heat using the concept of kinetic energy and model of matter

Suggested Unit Plan

It is recommended that Unit 2: From Structures to Properties, be completed as the second unit of Chemistry 2202.

September	October	November	December	January	February	March	April	May	June	
Unit 1: Stoichiometry				Unit 2: From Structures to Properties			Unit 3: Organic Chemistry			
Skills Integrated Throughout										

Covalent Bonding

Outcomes

Students will be expected to

43.0 illustrate and explain the formation of covalent bonds [GCO 3]

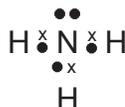
Focus for Learning

In Science 9, students identified ionic and molecular (covalent) compounds based on the types of atoms involved. Students identified ionic compounds as involving a metal and a non-metal ion, whereas molecular compounds involved two or more non-metal atoms. In Science 1206, students extended their identification of ionic compounds to include multivalent metal ions and polyatomic ions.

Students were also introduced to properties of ionic and molecular compounds (but not metallic substances) in Science 1206; however, an explanation for these properties may not have been provided.

In Science 9, students represented the first 18 elements with Bohr diagrams; however, students may have simplified these diagrams using circles and dots to represent electron orbits and electrons. Students should be familiar with the terms valence electrons and valence energy level; this topic introduces the concept that compounds form to increase overall chemical stability. Individual atoms will react to obtain the filled valence electron structure of the nearest noble gas (octet rule). Teachers should ensure that students understand the stability of the noble gases and that the group number equals the number of valence electrons (for Group A elements).

Covalent Bond Formation (Molecular Compounds): Students should be able to explain the importance of electron sharing to create stability during covalent bond formation. They should use Lewis dot diagrams to show the formation of molecular compounds.



When discussing bond formation, teachers should address Lewis dot diagrams for molecules (i.e., compounds composed of only non-metals) with no more than two central atoms while discussing bond formation. In doing so, students should be able to explain as well as draw Lewis diagrams of molecules that contain

- bonding electron pairs;
- non-bonding pairs (lone pairs); and
- single, double, and triple covalent bonds.

Sample Performance Indicator

Draw Lewis dot diagrams for each compound below:

- | | | |
|----------------------------------|--|-----------------------------------|
| 1. CH ₄ | 5. C ₂ Br ₄ | 9. H ₂ CO |
| 2. Br ₂ | 6. C ₂ Cl ₂ | 10. N ₂ H ₄ |
| 3. C ₂ H ₆ | 7. CBr ₂ F ₂ | |
| 4. CH ₃ OH | 8. C ₂ H ₂ Cl ₂ | |

Covalent Bonding

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Use Bohr diagrams of atoms to illustrate and explain the formation of covalent bonds.

Students may

- Draw Bohr diagrams for non-metal atoms and identify the valence electrons.

Connection

Students may

- Write a journal entry to answer the following questions:
 - How and why do atoms obtain a noble gas electron structure? Do they then become noble gases?
 - What structure does an unreactive element have?

Consolidation

Students may

- Use magnetic 'electron' manipulatives on a magnetic white board to show how electrons are shared during bonding. Round magnets of different colours will help show sharing of electrons.

Extension

Students may

- Research the structures and function of more complex molecular compounds. Share findings in a format of their choice.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (Teacher Resource [TR])

- pp. 20, 93

Chemistry: Newfoundland and Labrador (Student Resource [SR])

- pp. 210-218

Newfoundland and Labrador Teacher Resource & Solutions Manual (Digital)

Suggested

Resource Links: <https://bit.ly/2q0GY06>

- ChemSketch Design Program
- Molecular Shapes (building app)
- VSEPR Theory
- Covalent Bonding (video)
- Lewis Diagrams and VSEPR Models (videos)

Modelling Covalent Compounds

Outcomes

Students will be expected to

44.0 explain the structural model of a molecular substance in terms of the various electron pairs that define it [GCO 3]

3.0 *state a prediction and a hypothesis based on available evidence and background information* [GCO 2]

16.0 compile and display evidence and information, by hand or by computer, in a variety of formats including diagrams, flow charts, tables, graphs, and scatter plots [GCO 2]

23.0 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate idea, plans, and results [GCO 2]

Focus for Learning

Students should:

1. Explain and discuss the three-dimensional nature of molecules using Valence Shell Electron Pair Repulsion (VSEPR) theory.
2. Identify the central atom(s) and indicate the corresponding VSEPR shape.
3. Determine the shapes around the central atom in simple molecules (two central atoms) by applying VSEPR theory.

Students should be able to draw, from elements, the following molecules and name its shape:

1. Tetrahedral (e.g., CH_4)
2. Trigonal Pyramidal (e.g., NH_3)
3. V-Shape/Bent (e.g., H_2O)
4. Trigonal Planar (e.g., C_2H_4)
5. Linear (e.g., C_2H_2)

Students should complete a lab investigation in which the five molecular shapes are represented by modelling kits. They should use VSEPR Theory to predict shapes around central atoms and then construct models depicting the shape of simple covalent molecules. Students should choose a method of organization, draw and label shapes appropriately, and justify their choices.



Students should be able to relate shapes to the number of bonding and non-bonding pairs of electrons.

Students are required to create three-dimensional models of various molecular compounds, represent these models using VSEPR diagrams, and display their data in a table such as the one below:

Table 1: Shape, Name, and Diagram of Different Molecular Substances

Molecular Substance	Lewis Diagram	# Lone pairs around each central atom	# Bonding electron groups around each central atom	Name of Molecular Shape	Shape Diagram
CF_4					
NI_3					
OCl_2					
C_2Cl_4					
C_2F_2					

For elaboration on outcomes 3.0, 16.0, and 23.0, refer to the Integrated Skills unit.

Continued

Modelling Covalent Compounds

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Ask: Do you think every molecule is 2D? 3D? Discuss.

Students may

- Assemble molecules such as CO_2 and H_2O using marshmallows and toothpicks or Styrofoam™ balls and toothpicks. Discuss the shapes created.
- Fill in an entrance card to predict how C_2H_6 forms using Lewis dot diagrams.
- Use a modelling kit (e.g., marshmallows and toothpicks) to predict how C_2H_6 forms using Lewis dot diagrams.

Connection

Teachers may

- Set up the classroom so that students take on the role of unbonded electrons. Students must move around to form molecular shapes. Balloons (or other objects) may be used as electrons.

Students may

- Use a model kit to make as many different molecular shapes as possible. Discuss why the atoms have differing bonding amounts and positions.

Consolidation

Students may

- Select a larger molecular compound of their choice (e.g., C_8H_{18} , caffeine, acetaminophen), research the properties, and build an accurate model using Styrofoam™ balls and wooden dowels (or molecular model kits). Share with the class.
- Explain why H_2S is bent and not linear.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 91-93

Chemistry: Newfoundland and Labrador (SR)

- pp. 216, 222 (Investigations)
- pp. 219-228

Teaching and Learning Strategies: <https://bit.ly/2lrDSJl>

- Building Molecular Models

Continued

Modelling Covalent Compounds

Outcomes

Students will be expected to

44.0 explain the structural model of a molecular substance in terms of the various electron pairs that define it [GCO 3]

3.0 state a prediction and a hypothesis based on available evidence and background information [GCO 2]

16.0 compile and display evidence and information, by hand or by computer, in a variety of formats including diagrams, flow charts, tables, graphs, and scatter plots [GCO 2]

23.0 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate idea, plans, and results [GCO 2]

Focus for Learning

Attitude

Encourage students to

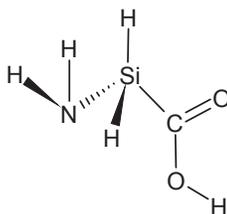
- work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas, and
- value the processes for drawing conclusions. [GCO 4]

Sample Performance Indicators

1. Draw and name the VSEPR shape for the following molecules:



2. Identify and name the shape of selected central atoms in complex molecules. Which atom has a tetrahedral shape? Trigonal planar? Trigonal Pyramidal?



Modelling Covalent Compounds

Sample Teaching and Assessment Strategies

Extension

Students may

- Use several model kits to build a network covalent solid or longer chained hydrocarbons/organics (e.g., CH_3COOH , C_8H_{18} , C_4H_8).
- Explore structures and properties of network covalent solids such as $\text{C}_{\text{diamond}}$, $\text{C}_{\text{graphite}}$, SiO_2 , and SiC .

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 91-93

Chemistry: Newfoundland and Labrador (SR)

- pp. 219-228

Intermolecular Forces

Outcomes

Students will be expected to

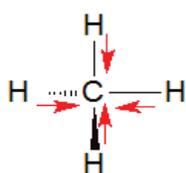
45.0 illustrate and explain hydrogen bonds and van der Waals' forces [GCO 3]

Focus for Learning

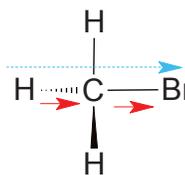
Students should be able to complete each of the following:

1. Explain and discuss electronegativity, polarity, polar covalent bonds, non-polar covalent bonds, and bond dipoles.
2. Predict polarity of molecules using the combination of bond dipoles and VSEPR shapes (see example below).
3. Define and explain intermolecular forces including van der Waals forces (London dispersion forces and dipole-dipole forces), and hydrogen bonding.
4. Identify the intermolecular forces present between molecules, based on their formula or structure (e.g., Given water, what are the intermolecular forces between the molecules?).
5. Make comparisons among London dispersion forces, dipole-dipole forces, and hydrogen bonding related to the strength of each.

Predicting Molecular Polarity (example)



Non-polar



Polar

Students are not expected to identify bond type based on electronegativity differences; however, they should be able to explain why one molecule may be more polar than another. For example, CH_3Br and CH_3F are both polar, but CH_3F is more polar due to the greater electronegativity of F in comparison to Br.

Sample Performance Indicator

Answer the following questions:

1. Why is CCl_4 non-polar and CCl_3I polar?
2. Determine whether the following molecules are polar or non-polar: CS_2 and $\text{C}_2\text{H}_3\text{F}$.

Intermolecular Forces

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Demonstrate the effect of intermolecular forces by using floating paper clips, needles, etc. on water (may also overfill a glass of water for this demonstration).
- Discuss and explain the unique properties of water, such as its expansion when in solid form.

Students may

- Search for a video of the movements of a water strider. Watch, discuss, and brainstorm how this is possible.
- Observe the bending of a slight stream of water with a statically charged hair brush (or balloon). Comparisons can be made by using non-polar liquids.

Connection

Students may

- Discuss the role of the Fe^{2+} ion in the hemoglobin protein in the blood. Determine polarity of O_2 and CO followed by a discussion of carbon monoxide poisoning.
- Compare the effects of attractive forces using magnets (one in each hand). Answer the following questions:
 - Do the forces exist if the magnets are arms length apart?
 - What happens as the magnets get closer together?
 - What happens when the magnets stick together?

Consolidation

Students may

- Determine the forces that exist in a variety of molecular compounds.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 89-104, 108

Chemistry: Newfoundland and Labrador (SR)

- pp. 231-251
- p. 258 (Investigation)

Suggested

Resource Links: <https://bit.ly/2q0GY06>

- Chemdoodle: Shapes of Molecules Design Program
- Bond and Molecular Polarity
- Videos
 - Polar & Non-Polar Molecules
 - Hydrogen Bonding
 - London Dispersion Forces
 - Dipole Forces
 - Intermolecular Forces and Properties of Molecular Compounds

Intermolecular Forces

Outcomes

Students will be expected to

46.0 identify and describe the properties of molecular substances
[GCO 3]

47.0 describe how intermolecular forces account for the properties of molecular compounds
[GCO 3]

10.0 use library and electronic research tools to collect information on a given topic
[GCO 2]

11.0 select and integrate information from various print and electronic sources or from several parts of the same source
[GCO 2]

16.0 *compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots*
[GCO 2]

Focus for Learning

Students should be able to complete the following:

1. Identify the types of intermolecular forces within pure molecular substances.
2. Relate the strength of London dispersion forces to the molecular size (number of electrons) and shape (complexity).
3. Compare the strengths of intermolecular forces of one compound with those of another compound.
4. Use the strength of intermolecular forces to predict the relative boiling and melting points of simple molecular compounds.

Students should research other properties (e.g., shape, density) of molecular compounds and explain (using an appropriate form such as a diagram, paragraph, etc.) how intermolecular forces contribute to those properties. They should pose questions, compare sources, and choose information that is relevant and valid. Students should have opportunities to choose the form they feel is most appropriate when presenting information.

For elaboration on outcomes 10.0, 11.0, and 16.0, refer to the Integrated Skills unit. Teachers may also wish to address and assess additional skill outcomes (e.g., SCOs 22.0, 23.0, 24.0).

Attitude

Encourage students to acquire, with interest and confidence, additional science knowledge and skills, using a variety of resources and methods, including formal research. [GCO 4]

Sample Performance Indicator

Use inquiry and prior learning to determine which has the highest boiling point. Justify your choice.

- a. Cl_2 or F_2 ? b. Cl_2 or C_4H_{10} ? c. H_2O or H_2O_2 ?

Intermolecular Forces

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Illustrate the effect that covalent/molecular bonding structures have on physical properties of substances by comparing the structure of diamond to graphite. Students are not required to know specific structures.

Students may

- Hold two small round magnets a centimetre apart. Move them past each other, first quickly and then slowly. Answer: Which is easier? Why? Relate to the effect of temperature on molecules.

Connection

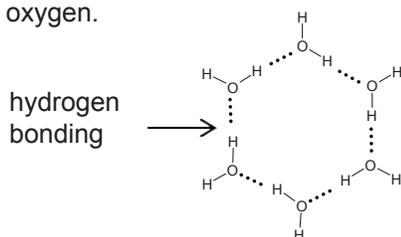
Teachers may

- Compare the relative strength of intermolecular forces to chemical bonding within compounds (covalent, ionic, and metallic).

Students may

- Discuss the potential impact upon our world if hydrogen bonding did not exist (consider water).
- Compare the intermolecular forces between two molecules where only one factor is varied.
- Write a journal entry to discuss the impact hydrogen bonding has on ice floating and on biochemistry (DNA).
- Construct a paper snowflake using the hydrogen bonding between hydrogen and oxygen.

Ice Crystal



Consolidation

Students may

- Complete a lab investigation on the properties of water or the properties of substances. Investigate the following physical properties:
 - Surface tension of water (e.g., needle on top of water)
 - Charging acetate (static electricity causing the bending of a stream of water with charged acetate)

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 89-104

Chemistry: Newfoundland and Labrador (SR)

- pp. 231-251
- p. 259 (Investigation)

Network Covalent Compounds

Outcomes

Students will be expected to

15.0 identify limitations of a given classification system and identify alternative ways of classifying to accommodate anomalies [GCO 2]

Focus for Learning

Classifications are human constructs as attempts to make sense of the world.

Students should be able to identify that SiO_2 , SiC, and C_n (diamond, graphite) do not exhibit properties that are typical of molecular compounds. They should be able to explain that they are a special type of molecular compounds called network covalent solids and have unique structures that result in properties different from those listed in the table of properties (p. 124 of this guide) of ionic and molecular substances (e.g., SiO_2 , SiC, and $\text{C}_{\text{diamond}}$ have extremely high melting and boiling points). It is not expected that students know how these compounds form. They should be able to relate the structure to melting and boiling points.

For elaboration on outcome 15.0, refer to the Integrated Skills unit. Teachers may also wish to address and assess additional skill outcomes (e.g., SCO 3.0).

Attitude

Encourage students to

- use factual information and rational explanations when analyzing and evaluating, and
- confidently evaluate evidence and consider alternate perspectives, ideas, and explanations. [GCO 4]

Sample Performance Indicator

Make predictions regarding the properties of SiO_2 and CO_2 . Research and discuss or present, based on given classification systems.

It is important for teachers to know that at first glance, students may think that both compounds will have similar properties. Further research and investigation into these two compounds will reveal the limitations of making such generalizations (i.e., when making generalizations, there are often examples that do not conform).

Network Covalent Compounds

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Discuss science specific examples of instances where generalizations have exceptions (e.g., metals are solids at room temperature—except mercury, atoms form either positive ions or negative ions—except hydrogen can form both).

Connection

Students may

- Offer reasons for limitations present in given classification systems (e.g., covalent bonds are stronger than intermolecular forces, thus melting points are higher for network covalent solids; metals are solids at 25 °C, but Hg is not).
- Predict the properties of a variety of compounds. Compare predictions with those of their peers. Discuss.

Consolidation

Students may

- Identify (from a list) whether substances are molecular (based on their chemical formula).

Extension

Students may

- Research network covalent solids such as diamonds to learn more on the topic of molecular (covalent) substances. Identify instances of where these types of materials are found.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 96, 106-116

Chemistry: Newfoundland and Labrador (SR)

- pp. 277-280

Suggested

Resource Links: <https://bit.ly/2q0GY06>

- Covalent Network Solids (video)

Ionic Bonding

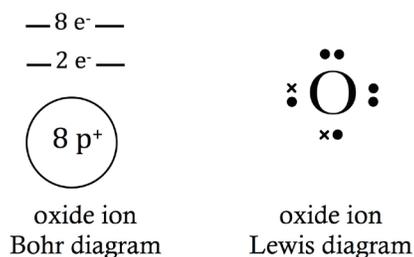
Outcomes

Students will be expected to

48.0 illustrate and explain the formation of ionic bonds [GCO 3]

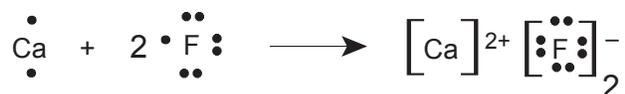
Focus for Learning

Bohr diagrams for atoms, not ions, were completed in Science 9. Though the focus of this outcome is on Lewis diagrams, Bohr diagrams for ions should be introduced to illustrate they have the same electron configuration as noble gases. Bohr diagrams were not addressed in Science 1206.



As previously noted, in reference to covalent bonds, this topic also includes the concept that compounds form to increase overall chemical stability. Students should be able to identify that noble gases are inert because they have filled valence levels. They should be able to relate the number of valence electrons to the position of the atom on the periodic table (for group A elements).

Ionic Bond Formation (Ionic Compounds): Students should be able to explain the reason for electron transfer in creating stability during ionic bond formation. They should also use Lewis dot diagrams to show the formation of an ionic compound. For example,



Sample Performance Indicators

- Draw Lewis dot diagrams to show bonding formation of each compound below (formula is given):
 - NaCl
 - BaCl₂
 - Sr₃N₂
 - MgO
 - Li₂S
- Draw the Lewis dot diagram for the compound formed between magnesium and nitrogen.
- Given the Lewis dot diagram of an ionic compound, write the chemical formula. Using the example above, write CaF₂.
- Using Lewis dot diagrams, explain the chemical formula for aluminum sulfide, Al₂S₃.

Ionic Bonding

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Review Bohr diagrams for atoms and the concept of valence electrons.
- Use Bohr diagrams of ions to illustrate and explain the formation of ionic bonds.

Students may

- Draw Bohr diagrams for atoms and identify valence electrons.

Connection

Students may

- Predict the charge of an ion and Lewis diagram based on the position of the atom in the periodic table.
- Write a journal entry to answer the following questions:
 - How and why do atoms form a noble gas electron structure? Do they then become noble gases?
 - What does the gain of electrons mean in terms of an atom's charge?
 - What is an ion and how is it formed?
 - What does a stable ion consist of?
 - What does an inert element consist of?

Consolidation

Students may

- Predict the empirical formula of an ionic compound using the Lewis dot diagrams.
- Select an ion that plays a role in the human body (e.g., Na^+). Write a report that outlines its function. Include information on why the atom form of that ion does not play the same role in the body.
- Compare the electronegativity of single atom cations with single atom anions.

Extension

Students may

- Research the definition of a radical. Expand to research the use of antioxidants to prevent free radicals.
- Draw a Lewis dot diagram for any polyatomic ion.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 106-116

Chemistry: Newfoundland and Labrador (SR)

- pp. 269-270

Ionic Structures and Properties

Outcomes

Students will be expected to

49.0 explain the structural model of an ionic substance in terms of the various bonds that define it
[GCO 3]

50.0 identify and describe the properties of ionic substances
[GCO 3]

51.0 describe how ionic bonding accounts for the properties of ionic compounds
[GCO 3]

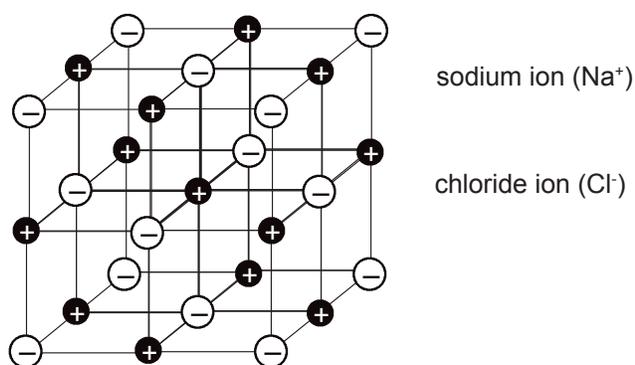
52.0 relate the properties of a substance to its structural model of ionic compounds
[GCO 3]

Focus for Learning

A common student misconception includes an understanding that ionic compounds exist as separate entities, similar to molecules; however, this does not occur. Rather than referring to 'molecules of NaCl'; students should refer to formula units representing the lowest ratio of ions.

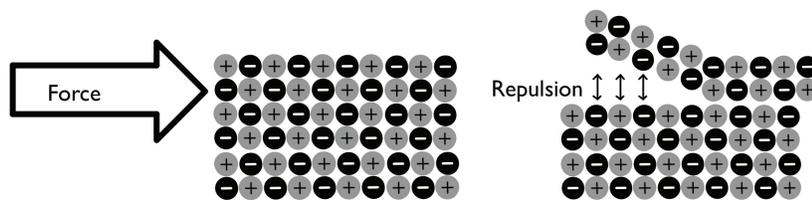
Students should be able to explain a crystal lattice structure and identify structures that are a one-to-one ratio of cations to anions such as in the diagram below.

Crystal Lattice of Sodium Chloride



Students should be able to use the theory of ionic bonding to explain the general properties of ionic compounds:

- Ability to conduct electricity when molten or in aqueous solution – ions are charged particles, but ionic compounds can only conduct electricity if their ions are free to move in a solution or when melted
- Brittleness – shatters when a force is applied



- High melting and boiling points – a lot of energy is needed to break the strong ionic bonds; they are strong attractions

Ionic Structures and Properties

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Share images or videos of a steel framed building in the middle of construction. This will help students visualize the three-dimensional nature of a crystal lattice structure.
- Use a hammer to break large pieces of rock salt. Discuss how the crystal structure is responsible for cleavage (how it fractures or shatters).

Students may

- Respond to and discuss the following questions:
 - Can a piece of road salt be crushed with your hand?
 - How can it be hard, yet brittle?
 - Why are its edges jagged?
- Observe salt crystals with a magnifying glass or stereo microscope. Answer: Do you notice any regularities in the crystals? Explain. A number of different ionic compounds can be used to show variety in shape, colour, and translucence.

Connection

Teachers may

- Model a 3D drawing of the lattice structure. Model a think-aloud of the components of the structure.
- Share pictures of lattice structures that are not one-to-one ratio (e.g., MgCl_2).

Students may

- Explain why ionic compounds will not conduct electricity in their solid states.
- Question the statement: We put $\text{NaCl}(s)$ on our fries but dare not put $\text{Na}(s)$ on them. Participate in a discussion regarding the difference in reactivity between a Na atom and a Na^+ ion (online videos of Na reactions with water may help to reinforce this idea).

Consolidation

Students may

- Draw crystal lattice structures for ionic compounds with one-to-one ratios. Relate the structure to the physical properties (such as brittleness) of ionic compounds.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 106-116

Chemistry: Newfoundland and Labrador (SR)

- pp. 273-274

Suggested

Resource Links: <https://bit.ly/2q0GY06>

- Ionic Bonding

Metallic Structures and Properties

Outcomes

Students will be expected to

53.0 illustrate and explain the formation of metallic bonds [GCO 3]

54.0 identify and describe the properties of metallic substances [GCO 3]

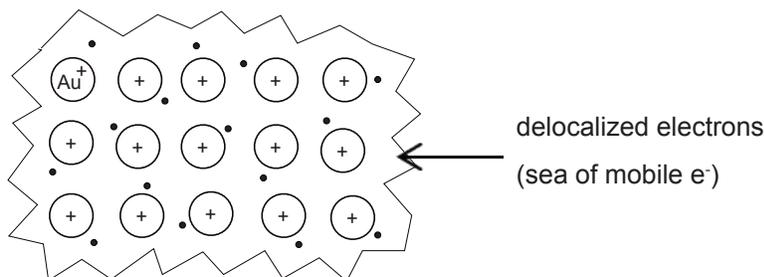
55.0 describe how metallic bonding accounts for the properties of metals [GCO 3]

56.0 relate the properties of a substance to its structural model [GCO 3]

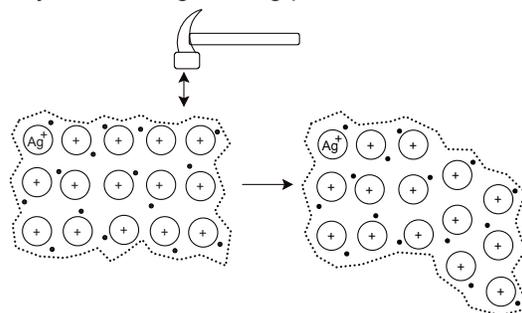
Focus for Learning

In Science 9, students studied properties of metals; however, they were not expected to explain these properties in terms of metallic bonding.

Metallic Bond Formation (Metallic Substances): Students should be able to describe the electron sea model of metallic bond formation as well as draw a diagram to represent that model. An example of the diagram is provided below:



Students are expected to be able to use the electron sea model to describe the properties of metallic substances in terms of conductivity, malleability, and boiling/melting point.



Attitude

Encourage students to

- value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not, and
- show a continuing and more informed curiosity and interest in science and science-related issues. [GCO 4]

Sample Performance Indicators

1. Illustrate and explain metallic bonding that occurs in copper.
2. Create a graphic to compare and contrast metallic versus ionic bonding.

Metallic Structures and Properties

Sample Teaching and Assessment Strategies

Activation

Students may

- Recall and list the physical properties of metals.

Connection

Students may

- Bend a paper clip back and forth until it breaks. Answer and discuss the following questions:
 - What did you observe?
 - Did it get warm?
 - Why did it break?
- Discuss answers to the following questions:
 - Why are metals, rather than plastic, used for cooking?
 - Why can a piece of metal be reshaped?

Consolidation

Students may

- Research and present findings on why some metals are better conductors than others.

Extension

Students may

- Research the chemical make-up and properties of different alloys such as sterling silver, brass, and bronze. Present findings to the class.
- Research the importance of being aware of metal fatigue in the engineering and construction industry.
- Generate a list of amazing metal facts. The list could contain the most malleable metal, the best conductor of electricity, the strongest, etc.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 106-116

Chemistry: Newfoundland and Labrador (SR)

- pp. 275-276

Suggested

Resource Links: <https://bit.ly/2q0GY06>

- Metallic Bonding

Solubility

Outcomes

Students will be expected to

57.0 describe the process of dissolving, using concepts of intramolecular and intermolecular forces [GCO 3]

16.0 compile and display evidence and information, by hand or by computer, in a variety of formats including diagrams, flow charts, tables, graphs, and scatter plots [GCO 2]

23.0 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate idea, plans, and results [GCO 2]

Focus for Learning

In Science 7, students were introduced to homogeneous and heterogeneous mixtures. In Chemistry 2202, they should be able to explain that the degree of solubility depends on both the bond types within a compound including covalent (intramolecular) or ionic and the intermolecular forces between molecules. Students should also be able to complete the tasks below:

- Explain that solutions are homogeneous mixtures at the particle level and do not involve a chemical change.
- Describe and discuss the solubility of ionic and molecular compounds in polar and non-polar solvents.
- Explain how polar molecular and ionic compounds may form aqueous solutions, based on similarities between solute forces and solvent forces (i.e., like dissolves like).

Students should describe the process of dissolving by explaining dipole-dipole interactions for molecular substances and ion-dipole interactions for ionic substances. They should note that solubility rules are generalizations that have exceptions (e.g., despite being a non-polar compound, when O_2 dissolves in water, it does not follow the generalization that like dissolves like).

Students should complete a lab investigation to determine the solubility of various substances as compared to each other. They should observe solubility and miscibility of polar molecular compounds, non-polar molecular compounds, and ionic compounds. Students should also conduct tests to identify compounds as soluble or insoluble. They should use small amounts of each liquid and solid for each. Suggested tests are listed below:

- | | | |
|-------------------------|---------------------------|--------------------------|
| • NaCl and CH_3OH | • NaCl and mineral oil | • NaCl and H_2O |
| • CH_3OH and H_2O | • Cooking oil and H_2O | • I_2 and H_2O |
| • I_2 and mineral oil | • Cooking and mineral oil | • Mineral oil and H_2O |



Suggested follow-up questions:

1. Since 'like dissolves like', identify the polarity of mineral oil, cooking oil, iodine, and methanol.
2. Why don't we try to classify substances like sodium chloride as either polar or non-polar?
3. What generalization can you make about the solubility of substances like sodium chloride in polar substances?
4. What generalization can you make about the solubility of substances like sodium chloride in non-polar substances?

For elaboration on outcomes 16.0 and 23.0, refer to the Integrated Skills unit. Teachers may also wish to address and assess additional skill outcomes (e.g., SCOs 12.0, 13.0, 25.0).

Sample Performance Indicator

Which of the following substances are expected to dissolve in water? Explain your choice.

1. CCl_4
2. $Mg(NO_3)_2$
3. CH_3OH
4. S_8
5. CH_2Cl_2
6. NH_3

Solubility

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Conduct a demonstration using magnetic and glass marbles in a petri dish (when mixed, the two magnetic marbles group together). Repeat with two different colour glass marbles.

Students may

- Discuss the food industry dilemma of mixing oils and water (e.g., using emulsifiers to make salad dressing).

Connection

Students may

- Identify the connection between polarity of solute and solvent and solubility (based on their results above).
- Discuss pesticide solubility and environmental impact (completed in Science 1206 Ecology unit) and relate it to the concept of solubility.

Consolidation

Students may

- Complete a lab investigation based on matching solutes and solvents.
- Design and prepare their own salad dressing or mayonnaise. Identify component parts and discuss the need for additives such as emulsifiers, stabilizers, and preservatives.
- Draw the position of the particles to represent
 - table salt dissolved in water, and
 - table sugar dissolved in water.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 96, 106-116

Chemistry: Newfoundland and Labrador (SR)

- pp. 281-289
- pp. 288, 292-295 (Investigations)

Solubility

Outcomes

Students will be expected to

33.0 explain the variations in the solubility of various pure substances, given the same solvent
[GCO 3]

58.0 determine the molar solubility of a pure substance in water
[GCO 3]

59.0 explain the effect of solutes on the melting point of solid water, using intermolecular forces
[GCO 3]

Focus for Learning

Students should be able to predict the variations in the solubility of ionic compounds in water using the solubility table. Students should be able to explain variations in solubility of ionic compounds in the following general way: ionic compounds have a low solubility in water when the forces of attraction between ions are greater than the force of attraction between the ions and the water molecules.

In Unit 1, students predicted the solubility of ionic compounds in water.

Solubility Rules for Ionic Compounds in Water at 25°C.

Ions	Group 1 NH ₄ ⁺ H ⁺ (H ₃ O ⁺)	ClO ₃ ⁻ NO ₃ ⁻ ClO ₄ ⁻	Cl ⁻ Br ⁻ I ⁻	CH ₃ COO ⁻	SO ₄ ²⁻	S ²⁻	OH ⁻	PO ₄ ³⁻ SO ₃ ²⁻ CO ₃ ²⁻
(aq) high Solubility (> 0.1 mol/L)	all	all	most	most	most	Group 1 Group 2 NH ₄ ⁺	Group 1 NH ₄ ⁺ , Sr ²⁺ Ba ²⁺ , Tl ⁺	Group 1 NH ₄ ⁺
(s) low Solubility (< 0.1 mol/L)	none	none	Ag ⁺ , Tl ⁺ Hg ₂ ²⁺ , Hg ²⁺ Cu ⁺ , Pb ²⁺	Ag ⁺ Hg ₂ ²⁺	Ca ²⁺ , Sr ²⁺ Ba ²⁺ , Ra ²⁺ Pb ²⁺ , Ag ⁺	most	most	most

Students should be able to use molecular forces to explain the effect of solutes on the melting point of solid water. They should understand that to form ice, a network of stable hydrogen bonds must be formed. When solute particles disrupt this network, it is more difficult for hydrogen bonds to form. The kinetic energy (temperature) of water must be lower for the structure to develop. The concept of kinetic energy (temperature) was covered in the Science 7 Heat unit.

Sample Performance Indicator

Predict the solubility of the following compounds in water:

1. Ca(NO₃)₂
2. KBr
3. BaSO₄
4. Ag₂SO₄
5. CuCl
6. PbCO₃
7. NiCl₂
8. NaOH
9. K₂CO₃
10. FeBr₃

Solubility

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Conduct a demonstration where they attempt to dissolve a variety of salts in water (e.g., NaCl, KMnO_4 , CuCl, BaSO_4). Discuss observations.

Students may

- Brainstorm reasons for the differences observed in the teacher demo above.
- Respond to the questions:
 - During the winter months in Newfoundland and Labrador, why is salt used on some roads while sand is used on others?
 - Why is a mixture of salt and sand sometimes used?
 - Why do the percentages of salt and sand vary?

Connection

Teachers may

- Demonstrate that a saturated calcium chloride solution will not freeze overnight in a freezer but a test tube of water will freeze.

Students may

- Answer the following questions based on the solubility chart:
 1. Which group of metal ions will form compounds all having high water solubility?
 2. What can be said about all compounds containing the ammonium ion?
- Participate in a lab investigation in which they create their own solubility table. The concept of high solubility and low solubility can be explored using a conductivity test and deionized water.

Extension

Students may

- Investigate the different freezing point depressions caused by equal concentrations of NaCl and CaCl_2 .

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 106-116

Chemistry: Newfoundland and Labrador (SR)

- pp. 282-283

Classifying Compounds: Properties

Outcomes

Students will be expected to

60.0 classify ionic, molecular, and metallic substances according to their properties [GCO 3]

4.0 identify the theoretical basis of an investigation and develop a prediction and a hypothesis that are consistent with the theoretical basis [GCO 2]

5.0 develop appropriate sampling procedures [GCO 2]

Focus for Learning

Students should be able to qualitatively compare melting and boiling points of molecular compounds to those of ionic, metallic, and network covalent substances. They should be able to explain that the melting and boiling points of metallic substances vary; however, they are generally higher than molecular substances.

Physical Property	Ionic	Molecular	Metals
State at Room Temperature	solid	solid, liquid, or gas	solid (except Hg)
Melting Point	very high	low (most), except network covalent solids	varies
Boiling Point	very high	low, (most) except network covalent	high
Solubility (in water)	see solubility table	varies	does not dissolve
Electricity	conducts in aqueous or liquid (molten) states	does not conduct in any state	conducts in solid and liquid (molten) states
Malleability	brittle and hard	varies	malleable/ductile
Examples	NaCl	H ₂ O	Cu

In Science 9, students completed an investigation comparing properties of metals and non-metals. In Science 1206, they completed an investigation classifying substances as either ionic or molecular compounds based on their properties; however, an explanation of those properties was not required during the analysis.

Students should provide a rationale, as well as develop a prediction and hypothesis before designing and completing a lab investigation. In the lab, students should be able to classify unlabelled substances as metallic, ionic, or molecular based on their properties. Substances may include sodium chloride, copper wiring, vegetable oil, acetic acid, sugar, vitamin C, an antacid, and/or cornstarch.



For example, teachers can provide a variety of chemicals and ask students to determine tests they should use to classify the substances as molecular, ionic, or metallic. These tests should include solubility and conductivity. The chemicals provided can include metals such as copper wire or aluminum foil as well as molecular and ionic compounds that differ in their solubility in water. For example, include table salt, table sugar, calcium carbonate (Tums), and cornstarch. The distinguishing property will then be conductivity.

After completing the lab investigation, students should be able to classify substances as ionic, molecular, or metals, based on their properties. In their analysis, they should also be able to provide an explanation of the properties.

For elaboration on outcomes 4.0 and 5.0, refer to the Integrated Skills unit. Teachers may also wish to address and assess additional skill outcomes (e.g., SCOs 1.0, 2.0, 3.0, 6.0, 9.0, 12.0).

Classifying Compounds: Properties

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Demonstrate different properties of molecular, ionic, and metallic substances using characteristic substances from each category (e.g., oil, sugar, copper wire, aluminum foil, table salt).

Students may

- Create a Frayer™ model to organize prior knowledge about each substance type. For example,

Definition		Illustration
Examples		Non-examples

Connection

Students may

- Discuss the following question: Why does household wiring use copper metal, Cu(s), instead of something like copper(II) chloride, CuCl₂(s)? Show their understanding that while copper is present in both elemental Cu(s) and the ionic compound CuCl₂(s), the form of copper determines its real world properties.
- Discuss why other metallic substances besides Cu are not used for electrical purposes (cost, availability, safety, level of conductivity, etc.).
- Research the chemical composition and properties of various minerals and identify them as ionic, molecular, or metallic (e.g., halite, quartz, gold). This provides a cross-curricular opportunity with Earth Systems.

Consolidation

Students may

- Create a flowchart of diagnostic tests to determine the substance type based on their properties.
- Rank the following substances in order of increasing boiling points: SiC, C₂H₆, CH₃OH, F₂, Mg, and CaCl₂.
- Populate a blank version of a chart (similar to the chart on p.124) to show they understand the properties of metallic, ionic, and molecular substances.
- After inspection, it was determined that a compound, XCl₃, has a very high melting point and is solid at room temperature. Suggest the identity of element X. Explain the process used to arrive at the answer.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 29, 97, 106-116

Chemistry: Newfoundland and Labrador (SR)

- pp. 266-301
- p. 294 (Investigation)

Teaching and Learning Strategies: <https://bit.ly/2lrDSJI>

- Identifying Substances from Properties

Material Properties and Society

Outcomes

Students will be expected to

- 61.0 analyze and describe examples where technologies were developed based on scientific understanding [GCO 1]
- 62.0 analyze from a variety of perspectives the risks and benefits to society and the environment of applying scientific knowledge or introducing a particular technology [GCO 1]
- 63.0 analyze examples of Canadian contributions to science and technology [GCO 1]

Focus for Learning

Students should research and analyze properties and materials of one or more technologies from a chemistry perspective (involving bonding, structures, and properties of materials). They should have multiple opportunities for inquiry, discussion, and questioning or debate in order to fully understand effects on the environment when scientific knowledge is used to introduce a new technology.

Students should choose a familiar object (to provide a clearer context), conduct research, and share their analysis. They should determine and evaluate the risks and benefits to society when a new technology is introduced.

Students may follow the steps below when completing research:

1. In groups, choose one object, then find one video and one article that addresses the chemistry behind the object.
2. Discuss how both the video and the article relates to unit topics.
3. Share findings with the class (e.g., video, infographic, podcast).

Research examples include those listed below:

- Composite hockey sticks and/or pucks (i.e., materials used)
- Disinfection of water (e.g., ozone vs. chlorine)
- Smart phone chemistry (e.g., glass types, oil repelling film, use of rare earth metals, battery, conflict minerals)
- Snowmobiles or other motorized vehicles (e.g., fuel types, compounds used for the body, how parts are recycled, elements used in spark plugs, light bulbs, and batteries)
- Tempered glass (e.g., windshields, Prince Rupert's Drop)
- Tooth fillings (e.g., alloys, composites)

Students should build their own knowledge related to Canadian contributions to science and technology. Reading about and discussing notable Canadian chemists such as Gerhard Herzberg and John Polanyi will help build knowledge and understanding.

Students should also research discoveries made at Canadian institutions when some of the primary persons involved were not Canadian (e.g., the discovery of noble gas compounds at the University of British Columbia by Dr. Neil Bartlett).

Attitude

Encourage students to be aware of the direct and indirect consequences of their actions, [GCO 4]

Sample Performance Indicator

Create a timeline to trace the evolution of materials used in hip and knee replacements (or a similar technological advance). Write a one to two page report to analyze the risks, benefits, and long term implications. Discuss Canadian advancements and contributions.

Material Properties and Society

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Model various components of the research project described in Focus for Learning (column 2).
- Use the various compositions of hockey sticks to illustrate how properties of different materials affect their function.

Connection

Teachers may

- Share information on and discuss a variety of materials with different properties. Suggestions include aerogels, metal foams, and Kevlar.
- List materials that may have an important effect on future manufacturing. These may include bio-inspired plastic, ultra-thin platinum, mega magnets, designer nano-crystals, rock-solid coating, electric ink. Ask students to predict effects.

Students may

- Discuss the following question: How does Product Development Chemistry (such as suitable solvents in paint, e.g., d-limonene) lead to technologies based on scientific understanding?
- Find and record information on man-made versus natural diamonds. Answer: How are they the same? How are they different? Share an opinion that outlines their own preference.

Consolidation

Students may

- Compare the use of ozone versus chlorine to disinfect water. Present findings using graphic and written form.
- Research and share findings on the use of various elements, alloys, and composites in sports equipment (e.g., boron and carbon in racquets and hockey sticks; aluminum, carbon, and titanium in bicycle frames).
- Research to determine Canadian scientists' contributions, in terms of academic research or contributions to chemistry in industry. Share results in the form of a one minute video (similar to a heritage minute).
- Create a comparison chart or diagram to relate van der Waals forces to the structure of DNA.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- p. 108

Section Three:
Specific Curriculum Outcomes

Unit 3: Organic Chemistry

Focus

Organic chemistry is the study of the molecular compounds of carbon. Students will learn about the reactions chemists use to synthesize carbon based structures. They will study the diversity of organic compounds and illustrate structural formulas for a variety of organic isomers. Students will determine to which families various organic compounds belong as well as write and balance chemical equations. They will be given opportunities to discover how the classification of organic molecules into different groups depends on the type of bonding and atoms present.

Scientific inquiry is an important component of this unit. Emphasis is placed on the development of skills related to posing questions, making predictions, making and recording observations and measurements, analyzing and interpreting recorded data to identify emerging patterns, and communicating learning.

Outcomes Framework

GCO 1 (STSE): Students will develop an understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology.

- 62.0 analyze from a variety of perspectives the risks and benefits to society and the environment of applying scientific knowledge or introducing a particular technology
- 65.0 explain how a major scientific milestone revolutionized thinking in the scientific communities
- 66.0 explain how scientific knowledge evolves as new evidence comes to light
- 72.0 provide examples of how science and technology are an integral part of their lives and their community
- 73.0 debate the merits of funding specific technological endeavours and not others
- 75.0 describe and evaluate the design of technological solutions and the way they function using scientific principles
- 76.0 analyze natural and technological systems to interpret and explain their structure and dynamics
- 77.0 identify various constraints that result in the trade-offs during the development and improvement of technologies
- 79.0 distinguish between scientific questions and technological problems
- 80.0 evaluate the design of a technology and the way it functions, on the basis of a variety of criteria that they have identified themselves

GCO 2 (Skills): Students will develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions.

- 1.0 define and delimit problems to facilitate investigation
- 2.0 design an experiment identifying and controlling major variables
- 11.0 select and integrate information from various print and electronic sources or from several parts of the same source
- 12.0 select and use apparatus and materials safely
- 13.0 demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials
- 15.0 identify limitations of a given classification system and identify alternate ways of classifying to accommodate anomalies
- 18.0 identify and apply criteria, including the presence of bias, for evaluating evidence and sources of information
- 19.0 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion
- 22.0 communicate questions, ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others
- 24.0 synthesize information from multiple sources or from complex and lengthy texts and make inferences based on this information
- 25.0 develop, present, and defend a position or course of action, based on findings

GCO 3 (Knowledge): Students will construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge.

- 64.0 explain the large number and diversity of organic compounds with reference to the unique nature of the carbon atom
- 67.0 classify various organic compounds by determining to which families they belong, based on their names or structures
- 68.0 write the formula and provide the IUPAC name for a variety of aliphatic compounds
- 69.0 define isomers and illustrate the structural formulas for a variety of organic isomers
- 70.0 write the formula and provide the IUPAC name for a variety of aromatic compounds
- 71.0 write the formula and provide the IUPAC name for a variety of hydrocarbon derivatives
- 74.0 write and balance chemical equations to predict the reactions of selected organic compounds
- 78.0 describe processes of polymerization and identify some important natural and synthetic polymers

GCO 4 (Attitude): Students will be encouraged to develop attitudes that support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society, and the environment.

Students are encouraged to:

- value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not
- appreciate that the applications of science and technology can raise ethical dilemmas
- value the contributions to scientific and technological developments made by people from many societies and cultural backgrounds
- acquire, with interest and confidence, additional science knowledge and skills, using a variety of resources and methods, including formal research
- confidently evaluate evidence and consider alternate perspectives, ideas, and explanations
- value the processes for drawing conclusions
- work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas
- have a sense of personal and shared responsibility for maintaining a sustainable environment
- project the personal, social, and environmental consequences of proposed action
- want to take action for maintaining a sustainable environment
- show concern for their safety and accept the need for rules and regulations
- be aware of the direct and indirect consequences of their actions

SCO Continuum

GCO 3: Knowledge		
Science 9 and Science 1206	Chemistry 2202	Chemistry 3202
<p>Science 9</p> <ul style="list-style-type: none"> identify and write chemical symbols for common elements describe changes in the properties of materials that result from some common chemical reactions investigate materials and describe them in terms of their physical properties and chemical properties <p>Science 1206</p> <ul style="list-style-type: none"> name and write formulas for some common ionic and molecular compounds, using the periodic table and a list of ions classify substances as acids, bases, or salts, based on their characteristics, name, and formula classify chemical reactions based on type 	<ul style="list-style-type: none"> explain the large number and diversity of organic compounds with reference to the unique nature of the carbon atom classify various organic compounds by determining to which families they belong, based on their names or structures write the formula and provide the IUPAC name for a variety of aliphatic compounds define isomers and illustrate the structural formulas for a variety of organic isomers write the formula and provide the IUPAC name for a variety of aromatic compounds write the formula and provide the IUPAC name for a variety of derivatives write and balance chemical equations to predict the reactions of selected organic compounds describe processes of polymerization and identify some important natural and synthetic polymers 	<ul style="list-style-type: none"> write and balance thermochemical equations including the combustion reactions of alkanes calculate the changes in energy of various chemical reactions using bond energy, heats of formation, and Hess's law describe various acid-base definitions up to and including the Brønsted-Lowry definition compare strong and weak acids and bases using the concept of equilibrium (theoretical) predict products of acid-base reactions compare strong and weak acids and bases using the concept of equilibrium (mathematical) explain how acid-base indicators function compare the molar enthalpies of several combustion reactions involving organic compounds

Suggested Unit Plan

It is recommended that Unit 3: Organic Chemistry, be completed as the final unit of Chemistry 2202.

September	October	November	December	January	February	March	April	May	June
Unit 1: Stoichiometry				Unit 2: From Structures to Properties			Unit 3: Organic Chemistry		
Skills Integrated Throughout									

Organic Compound Diversity

Outcomes

Students will be expected to

64.0 explain the large number and diversity of organic compounds with reference to the unique nature of the carbon atom
[GCO 3]

Focus for Learning

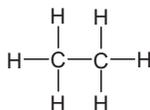
Students should be able to define organic molecules as molecular compounds composed of carbon atoms. Although all organic compounds contain carbon, there are some compounds of carbon that are not considered organic. For example, salts such as carbonates (CaCO_3 , NaHCO_3), oxides of carbon (CO , CO_2), cyanides (NaCN), cyanates (KSCN), and carbides (SiC) are classified as inorganic.

Teachers should explain that the unique properties of carbon contribute to the diversity of organic compounds. Students should be able to give reasons why approximately 95% of all known compounds are organic. Specifically, carbon is unique because it has the ability to

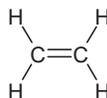
- make four covalent bonds (also studied in Unit 2);



- form multiple bonds (also studied in Unit 2);



ethane

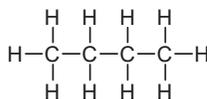


ethene



ethyne

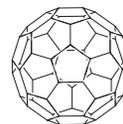
- bond in a variety of stable, relatively unreactive structures, such as chains, rings, and spheres;



butane

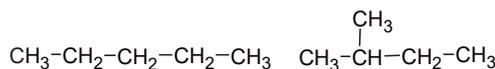


cyclopentane



buckminsterfullerene

- form isomers;

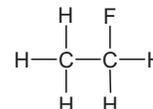
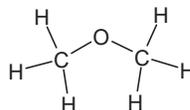
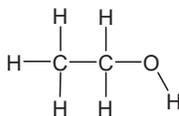


pentane

2-methylbutane

and

- form covalent bonds with other nonmetals to make derivatives.



Organic Compound Diversity

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Share examples of various organic compounds such as alcohols, steroids, aromatics, and hydrocarbons.

Students may

- Participate in a brainstorming activity to discuss why carbon is unique. Discuss:
 - What is the Lewis dot diagram for the carbon atom?
 - In terms of bonding, how does this dot diagram compare to those of other atoms (e.g., nitrogen, fluorine)?
 - When drawing Lewis dot diagrams of molecular models in Unit 1, how often was carbon a central atom?

Connection

Teachers may

- Lead a class discussion on the question: Are all carbon compounds also organic compounds?

Students may

- Research an organic molecule. Draw the structure and list characteristics of the compound (e.g., cinnamon).
- Draw Lewis structures of a variety of carbon molecules.
- Use carbon and hydrogen atoms from molecular modelling kits and create a stable compound based on bonding patterns studied in Unit 2, Structures to Properties. Draw their molecules on index cards (which may be used at a later time when discussing isomers).

Consolidation

Students may

- List natural sources of organic compounds.
- Identify a compound as organic or inorganic based on its composition.
- Explain the wide diversity of organic compounds in terms of
 - carbon's bonding capacity (to make four bonds),
 - ability to bond in a variety of stable unreactive structures (e.g., chains and rings), and
 - ability to form multiple bonds.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (Teacher Resource [TR])

- pp. 128-144

Chemistry: Newfoundland and Labrador (Student Resource [SR])

- p. 310

Newfoundland and Labrador Teachers Resource & Solutions Manual (Digital)

Suggested

Resource Links: <https://bit.ly/2q0GY06>

- Origin of Organic Chemistry & Naming Alkanes (video)
- Organic Chemistry Resources (Doc Brown)
- Organic Drawing and Nomenclature (video)

Organic Compound Diversity

Outcomes

Students will be expected to

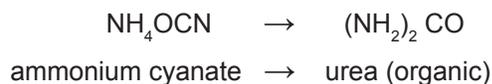
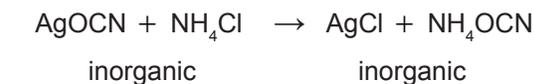
65.0 explain how a major scientific milestone revolutionized thinking in the scientific communities [GCO 1]

66.0 explain how scientific knowledge evolves as new evidence comes to light [GCO 1]

Focus for Learning

Students should be able to explain how a major milestone, specifically Wöhler's synthesis of urea, revolutionized scientific thinking.

Teachers should share that organic compounds were historically defined as compounds found in living organisms. That definition of organic compounds changed in 1828 when Friedrich Wöhler produced urea (a compound previously found only in urine of a living creature) from two inorganic compounds, as shown:



Attitude

Encourage students to value the contributions to scientific and technological developments made by people from many societies and cultural backgrounds. [GCO 4]

Sample Performance Indicator

In your own words, explain the following statement in relation to scientific thinking and organic chemistry:

Everything is tentative in science, "Shift happens."

Organic Compound Diversity

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Present seemingly contradictory information. Pose questions to students regarding their personal views. These may be related to alternative energy sources, controversial medical procedures, and medicine, (e.g., flu vaccine), pesticide and herbicide use (e.g., effect on bees vs. food production). Discuss how the way people think about things change as they gain new knowledge.
- Relate organic versus inorganic compounds as living (or once living) versus non-living from the Ecology unit in Science 1206.

Students may

- Provide personal views in response to the following prompts:
 - Use of the word 'organic' on many consumer products may be misleading.
 - Organic compounds which are used for pest control have an impact on society (recall pesticide use from Science 1206).
 - During the processing of an ethoxylated compound, a carcinogenic byproduct called 1,4-dioxane is created. Many ethoxylated compounds are used in cosmetic and personal care products, and commonly contain traces of 1,4-dioxane. This carcinogen has been found even in supposedly 'natural' brands.

Connection

Teachers may

- Ask students to imagine a world where all products are manufactured only from living things (e.g., natural vanilla vs. artificial vanilla). Discuss.

Students may

- List natural sources of organic compounds.
- Debate the advantages and disadvantages of synthesizing a molecule such as insulin to treat diabetes or reduce atmospheric CFCs. Students can debate the merits of discovering insulin to treat diabetes. On the contrary, manufacturing molecules have caused problems such as the production of CFCs (which depletes ozone).

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (SR)

- p. 310

Hydrocarbons

Outcomes

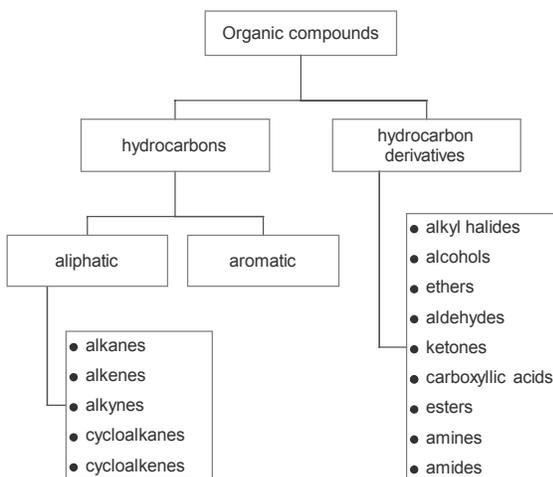
Students will be expected to

67.0 classify various organic compounds by determining to which families they belong, based on their names or structures [GCO 3]

68.0 write the formula and provide the IUPAC name for a variety of aliphatic compounds [GCO 3]

Focus for Learning

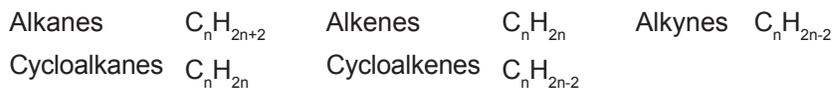
Teachers should discuss the importance of developing classification systems. Organic compounds are divided into two classes: hydrocarbons and hydrocarbon derivatives. Hydrocarbons are further sub-divided into aliphatics and aromatics.



There have been several naming conventions for organic compounds. Where indicated by preferred IUPAC name (PIN), teachers should follow the most recent conventions outlined by IUPAC.

Students should:

1. Write the formula and IUPAC name for simple aliphatic compounds.
2. Distinguish between aromatic and aliphatic compounds.
3. Distinguish between saturated and unsaturated hydrocarbons.
4. Name all prefixes for 1-10 carbons in a compound or alkyl group.
5. Write general formulas for the classifications below:



Teachers should note:

- For aliphatic straight chain compounds, students should name compounds with no more than a ten carbon chain and no more than three branches.
- Students are not expected to name complex branching structures (i.e., branches within a branch). All branches should be linear.
- For aliphatic cyclic compounds, students are expected to name and draw only compounds with no more than two branches.
- Alkene and alkyne structures will be limited to one multiple bond within the molecule.
- Naming systems used in this course follow IUPAC rules and recommendations.
- Teachers should use the Preferred IUPAC Name (PIN) that has the position of the functional group: pent-2-ene instead of 2-pentene.

Continued

Hydrocarbons

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Introduce an activity to help students name organic compounds. Tell students they met a woman with a 4-part name that included: Jane, Jr, Doe, Miss. Ask them to put the parts in order (Miss Jane Doe Jr). Ask students to explain how they were able to get the order of names correct (because they have an understanding of the human naming system, e.g., Prefix = Miss, Given Name = Jane, Surname = Doe, Suffix = Jr). Discuss how organic compounds follow a similar naming pattern:
 - Prefix = substituent
 - Given Name = carbon chain number
 - Surname = type of chain
 - Suffix = functional group

Students may

- Name complex molecules with multiple components by identifying each part individually. Put its name on a list and then view the list items as a puzzle that must be put together in a logical sequence.
- Participate in a brainstorming activity that discusses the need for an additional naming system for organic chemistry.

Connection

Students may

- Use molecular model kits to discuss the effect a multiple bond has on the physical properties within a carbon compound.
- Create cards to use in an activity where they will match the formula of compounds to the IUPAC names of compounds.
- Participate in a question and answer activity. Using the formula of a compound, take turns asking partners to name the compound from the formula and vice versa.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 128-144

Chemistry: Newfoundland and Labrador (SR)

- pp. 312-320, 324-326

Suggested

Resource Links: <https://bit.ly/2q0GY06>

- Naming Alkenes and Alkynes
- Aromatic and Cyclic Compounds (video)
- Basic Organic Nomenclature: University of Calgary
- Recognizing Derivatives by Structure (video)

Continued

Hydrocarbons

Outcomes

Students will be expected to
68.0 write the formula and
provide the IUPAC name
for a variety of aliphatic
compounds
[GCO 3]

Focus for Learning

Students should be able to determine

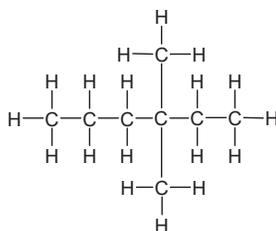
- IUPAC names;
- molecular formulas; and
- structural formulas (i.e., complete structural diagrams, condensed structural diagrams, skeletal structural diagrams, line structural diagrams);

for:

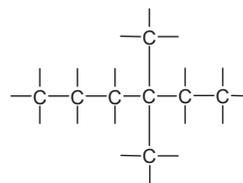
- alkanes,
- cycloalkanes (with maximum two branches),
- alkenes (one double bond),
- cycloalkenes (one double bond), and
- alkynes (one triple bond).

For example:

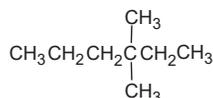
3,3-dimethyl hexane



complete structural diagram



skeletal diagram

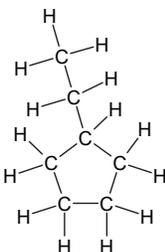
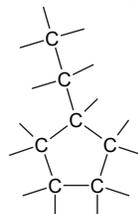


condensed structural diagram

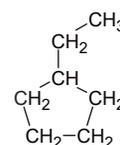
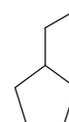


line (geometric) diagram

ethylcyclopentane

complete structural
diagram

skeletal diagram

condensed structural
diagramline (geometric)
diagram

Sample Performance Indicators

1. Given the chemical formula C_6H_{12} , determine types of organic compounds which fit this molecular formula.
2. Name and draw acceptable structure formats for 2,3-dimethylpentane and methylcyclobutene.

Hydrocarbons

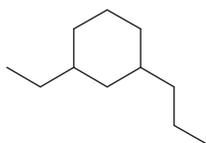
Sample Teaching and Assessment Strategies

Consolidation

Students may

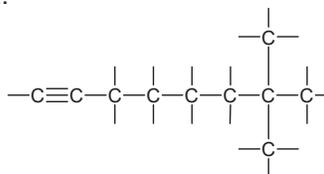
- Name the following straight-chain alkanes:
 - $C_{10}H_{22}$, C_3H_8 , C_8H_{18} , C_4H_{10} .
- Create and participate in an organic Jeopardy™ game.
- Draw an acceptable structure of C_5H_{10} . Classify it. Explain their choice, given that there are two acceptable types of organic compounds (alkenes and cycloalkanes).
- Use molecular models to make structures of ten carbon molecules studied.
- Compare structural formulas with molecular formulas. Answer: Are there any advantages for either?
- Draw a structural diagram for each of the following IUPAC names:

1.



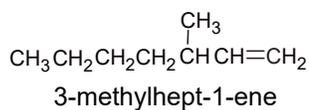
1-ethyl-3-propylcyclohexane

2.



7,7-dimethyloct-1-yne

3.



Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 128-130

Chemistry: Newfoundland and Labrador (SR)

- pp. 312-320, 324-326

Hydrocarbons

Outcomes

Students will be expected to

69.0 define isomers and illustrate the structural formulas for a variety of organic isomers [GCO 3]

22.0 communicate questions, ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others [GCO 2]

Focus for Learning

Students should be able to draw and name structural isomers including

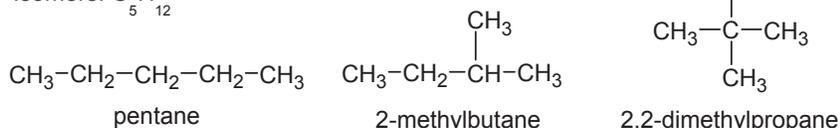
- structural isomers of alkanes (up to 6 carbons),
- structural isomers (including cyclic) of hydrocarbons with general formula C_nH_{2n} (up to 5 carbons), and
- structural isomers (including cyclic) of hydrocarbons with general formula C_nH_{2n-2} (up to 5 carbons).

It is important that students make the connection that alkenes and cycloalkanes with the same molecular formula will be isomers. Likewise, alkynes and cycloalkenes will also be isomers.

Teachers should note that geometric isomers (*cis* and *trans*) are not included with this outcome.

A common misconception for students is to confuse some compounds as isomers when they are in fact the same (e.g., pentane, C_5H_{12} , has three non-cyclic isomers). If students claim that there are more isomers, they have likely created twisted or mirror image versions of those below. If unsure as to whether they have created a new isomer, students can name the structure they have drawn. If this produces a unique name, a new isomer has been drawn. Alternatively, students can practice making models of potential structural isomers.

Isomers: C_5H_{12}



Students should collaboratively complete a lab investigation on isomerism using molecular modelling kits. One way to investigate isomerism is by constructing different structural arrangements for C_5H_{12} , C_5H_{10} , and C_5H_8 .



For elaboration on outcome 22.0, refer to the Integrated Skills unit. Teachers may also wish to address and assess additional skill outcomes (e.g., SCOs 12.0, 14.0, 16.0).

Attitude

Encourage students to value the processes for drawing conclusions. [GCO 4]

Sample Performance Indicator

Draw and name all isomers (cyclic and non-cyclic) for C_4H_8 .

Hydrocarbons

Sample Teaching and Assessment Strategies

Connection

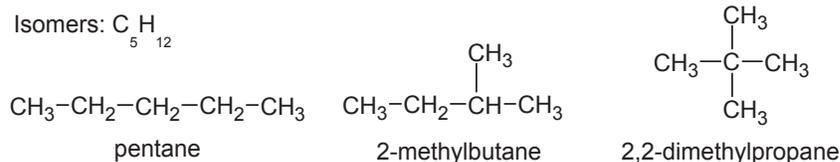
Teachers may

- Present the isomers methylpropane and butane, and address physical properties from Unit 2 (e.g., boiling point for methylpropane is $-11.7\text{ }^{\circ}\text{C}$ and butane is $-0.5\text{ }^{\circ}\text{C}$; should these or other isomer pairs be researched for their boiling points, the differences between the two values may be very small).

Students may

- View the three hydrocarbons below and explain how they are structurally the same. Explain how they are different. To aid their decision process, students may name the compounds.

Isomers: C_5H_{12}



- Recall the structures created in the introduction and relate these to their new knowledge of isomers.

Consolidation

Teachers may

- Discuss the tremendous diversity that can occur as a result of isomerism (e.g., C_5H_{12} has three, $\text{C}_{10}\text{H}_{22}$ has 75, $\text{C}_{15}\text{H}_{32}$ has 4387).

Students may

- Draw and name the two structural isomers of hydrocarbons with the molecular formula C_4H_{10} .
- Draw and name at least two structural isomers for
 - C_3H_6 ,
 - C_4H_6 , and
 - C_6H_{14} .
- Draw and name all structural isomers of C_5H_{10} . The cyclic isomers should have no more than one branch.

Extension

- Draw all cyclic isomers of C_6H_{12} which contain two branches.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 54, 128-130

Chemistry: Newfoundland and Labrador (SR)

- p. 314
- pp. 314, 327, 363 (Investigations)

Hydrocarbons

Outcomes

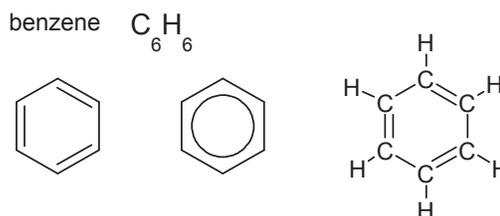
Students will be expected to

67.0 classify various organic compounds by determining to which families they belong, based on their names or structures [GCO 3]

70.0 write the formula and provide the IUPAC name for a variety of aromatic compounds [GCO 3]

Focus for Learning

Students should know how to draw the different representations of benzene, i.e.,



In presenting the above, teachers should discuss the special nature of bonding in benzene. Students should understand that the following resonance structures can be used to depict early conceptions of benzene structures (alternating single and double bonds).



The current model of benzene structure depicts electron delocalization as represented by the structure below.



It is important to note:

- Aromatic compounds are limited to those containing one benzene ring.
- Students are expected to name and draw only benzene compounds with no more than two branches.
- Students are not expected to name compounds using benzene as a branch (i.e., phenyl).
- When naming aromatic compounds, teachers should use systematic numbering instead of the ortho-, meta- and para- prefixes.

Sample Performance Indicator

Draw the structure for each of the following aromatic compounds:

- 1,3-dimethylbenzene
- 1-ethyl-2-propylbenzene
- 1-butyl-4-ethylbenzene

Hydrocarbons

Sample Teaching and Assessment Strategies

Connection

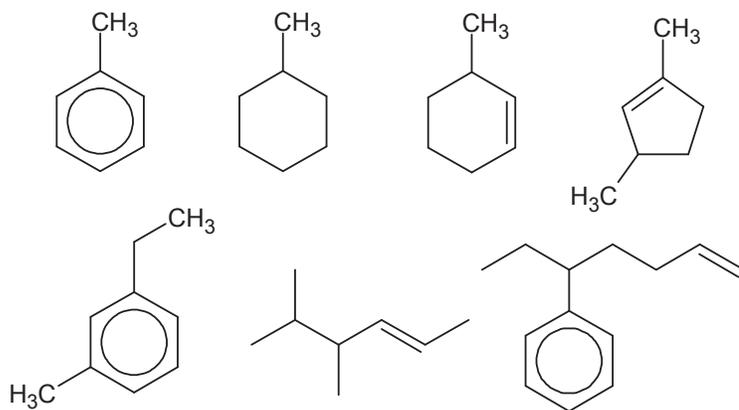
Teachers may

- Discuss how Kekule's concept of the ring structure of benzene revolutionized thinking in chemistry.
- Demonstrate the resonance nature of the early conceptions of benzene structure (alternating single and double bonds) using a molecular modelling kit.

Consolidation

Students may

- Research the work of Alfred Nobel, or any other chemist, with aromatic compounds. Present highlights to the class.
- Classify the following structures as aromatic or aliphatic.



Extension

Students may

- Examine and name other substituent groups such as halogens, phenyl, and nitro.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 128-144

Chemistry: Newfoundland and Labrador (SR)

- pp. 329-331

Hydrocarbon Derivatives

Outcomes

Students will be expected to

67.0 classify various organic compounds by determining to which families they belong, based on their names or structures
[GCO 3]

71.0 write the formula and provide the IUPAC name for a variety of hydrocarbon derivatives
[GCO 3]

Focus for Learning

Given the name or structure, students should be able to classify the following hydrocarbon derivatives:

- | | | |
|----------------|-------------------|---------|
| • alkyl halide | • aldehyde | • ester |
| • alcohol | • ketone | • amine |
| • ether | • carboxylic acid | • amide |

Students should observe that many organic compounds have several functional groups present and can fit into several different derivatives.

Students are not expected to name or draw structural isomers for the derivatives. Students should illustrate that certain families of derivatives are isomers of each other. These include alcohols and ethers; aldehydes and ketones; and carboxylic acids and esters.

To classify derivatives, students should be able to name and draw the structures of straight chain hydrocarbon derivatives (alkyl halide, alcohol, ether, aldehyde, ketone, carboxylic acid, ester, amine [primary], amide).

It is important to note:

- Naming and structural examples should be limited to one functional group in a compound and no branching (excluding alkyl halides).
- Students are not expected to identify alcohols or amines as being primary, secondary, or tertiary.
- Naming structures for ethers and amines should be limited to first carbon attachment to functional group (no branching).
- The preferred IUPAC name (PIN) has the position of the functional group indicated as follows: hexan-1-ol instead of 1-hexanol, pentan-2-one instead of 2-pentanone.
- The PIN for CH_3OCH_3 is methoxymethane instead of dimethyl ether.
- The PIN for $\text{C}_2\text{H}_5\text{CH}_2\text{NH}_2$ is propan-1-amine; not propyl amine. Naming amines will be limited to one alkyl group on the nitrogen.

For each derivative, students are required to recognize the functional group in a given diagram of a molecule and match it with the name (based on the suffix) and vice versa. Students should also be able to recognize common, functional groups in chemical formulas (e.g., the chemical formula of an carboxylic acid as being written as COOH within a chemical formula).

Sample Performance Indicator

Classify the following organic compounds by naming each functional group. Draw the complete structural diagram and name each compound.

- | | | |
|---|--------------------------------|-------------------------------|
| 1. $\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$ | 4. HCOOH | 7. CH_3CHO |
| 2. $\text{CH}_3\text{CH}_2\text{OH}$ | 5. $\text{CH}_3\text{COOCH}_3$ | 8. CH_3NH_2 |
| 3. CH_3OCH_3 | 6. CH_3CONH_2 | 9. CH_3COCH_3 |

Hydrocarbon Derivatives

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Present students with chemical formulas of familiar organic substances. For illustration purposes, these chemical formulas may have one or more functional groups (e.g., vinegar, methanol, lactic acid, aspirin, formaldehyde). The connection can be made between the functional group and derivative type.

Connection

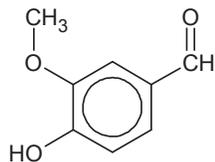
Students may

- Identify the group name of a series of functional groups.
- Participate in a matching activity with the names of the groups on one set of cards and structural diagrams of the groups on another set of cards.
- Use (individually or with a group), an interactive website (e.g., Sciencegeek™) which allows them to identify functional groups.

Consolidation

Students may

- Classify the functional groups in vanillin.



- Name and draw the ether and the alcohol with the chemical formula C_2H_6O . One of these compounds has a boiling point of 78 and the other has a boiling point of -24. Match each drawn structure to its boiling point. Justify.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 128-144

Chemistry: Newfoundland and Labrador (SR)

- pp. 334-358

Hydrocarbon Derivatives

Outcomes

Students will be expected to

15.0 identify limitations of a given classification system and identify alternate ways of classifying to accommodate anomalies [GCO 2]

Focus for Learning

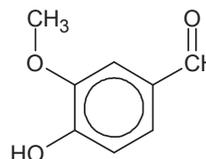
Students should examine how and why common names, rather than IUPAC names, are still widely used in the chemistry community. This is in part due to their familiarity and tradition (similar to the continued use of pounds and inches). With experience, chemists come to know these names and that IUPAC and common names are often interchangeable.

Due to either the complexity or the familiarity of certain organic compounds, IUPAC can become cumbersome and not practical. For example, toluene was named because it was first obtained by distilling tolu balsam. It is known widely as a solvent. Vanilla has a structure that produces a complex name using IUPAC naming rules, 4-hydroxy-3-methoxybenzaldehyde. It is much easier to use the common name vanilla.

It is important to note that students are responsible only for naming aromatic compounds with two branches; vanillin is used here to illustrate why common names are sometimes needed.



IUPAC: methylbenzene
common name: toluene



IUPAC: 4-hydroxy-3-methoxybenzaldehyde
common name: vanillin

For elaboration on outcome 15.0, refer to the Integrated Skills unit.

Sample Performance Indicator

Identify familiar organic compounds which are recognized by their common name. Investigate and discuss their IUPAC name (e.g., vinegar, alcohol, wood alcohol, rubbing alcohol, acetone, glucose, vitamins).

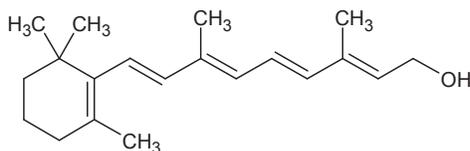
Hydrocarbon Derivatives

Sample Teaching and Assessment Strategies

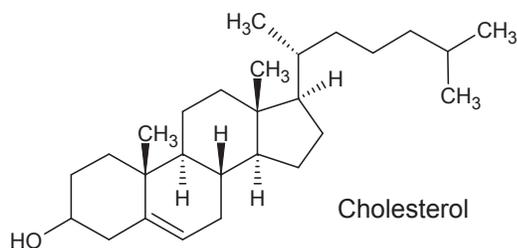
Activation

Teachers may

- Present complex structural diagrams for compounds that are familiar by their common name. Ask students to consider IUPAC naming before presenting the common name. Suggestions include the following:



Retinol or Vitamin A



Cholesterol

Connection

Students may

- Brainstorm and discuss reasons for the use of common names for chemical substances (e.g., why we call H₂O water and not dihydrogen monoxide).

Consolidation

Students may

- Create a blog or other written form to explain why it is practical for certain molecules (like sucrose) to have a common name.
- Find and list organic compounds that have a common use. Note the use of common names for conventional substances such as cinnamon.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 128-144

Chemistry: Newfoundland and Labrador (SR)

- pp. 328-330, 348-351

Hydrocarbon Derivatives

Outcomes

Students will be expected to

72.0 provide examples of how science and technology are an integral part of their lives and their community [GCO 1]

73.0 debate the merits of funding specific technological endeavours and not others [GCO 1]

Focus for Learning

Students should be able to discuss science and technology as an integral part of their lives and of society in general. They should also be able to understand the differences among different types of funding for technological endeavours (e.g., the merits of funding for the development of drugs to combat AIDS vs. research on alcoholism).

Discussions should also cover a range of topics which include hydrocarbon derivatives and some of their uses. Some examples are listed below:

- Acetaminophen is an amide used to reduce pain and fever.
- Ethyl methanoate is one of the esters responsible for the aroma of fresh raspberries.
- Methanoic acid is a carboxylic acid used as a toxin by ants.
- Methanol is an alcohol used in antifreeze and ethanol is an alcohol used as an antimicrobial agent.

Students will find it helpful to use research to show how science and technology fit into their lives. Question and answer periods, small and large group discussions, and debates will help broaden students' understanding of the world around them as well as their understanding of the ideas and opinions of others.

Attitude

Encourage students to

- value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not, and
- appreciate that the applications of science and technology can raise ethical dilemmas. [GCO 4]

Sample Performance Indicator

Research the technology behind high performance clothing such as Gore-Tex™. Discuss observations with a partner and then with the class.

Hydrocarbon Derivatives

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Pose the discussion topic: Explain how your life would be different if we did not have
 - antibiotics,
 - artificial sweeteners,
 - food preservatives, and/or
 - prescription drugs.

Students may

- Compile a list of organic compounds that exist in substances used every day. Examples include: food sources, pesticides, petroleum products, pharmaceuticals.

Connection

Students may

- Discuss answers to the following questions:
 - Why are organic compounds added to food products?
 - What impact can these additives have on human health?
 - What are the societal implications of the use of organic chemicals to control pests in agricultural chemistry?
 - What methods should be used to safely dispose of volatile organic compounds such as motor oil or paint?

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 128-144

Chemistry: Newfoundland and Labrador (SR)

- pp. 312, 320-321, 324, 334, 338, 342, 345

Writing and Balancing Organic Chemical Reactions

Outcomes

Students will be expected to

74.0 write and balance chemical equations to predict the reactions of selected organic compounds [GCO 3]

Focus for Learning

Students should be able to balance chemical reactions for

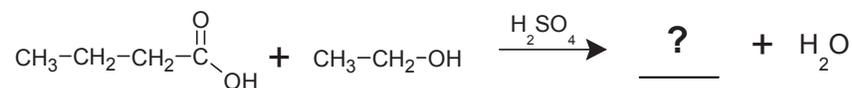
- cracking (a larger substance is broken down into smaller ones),
- reforming (two or more small molecules to make a larger one or one unbranched molecule to make a branched isomer),
- complete combustion reactions (limited to hydrocarbons only),
- substitution (single) of a halogen for a straight chain alkane,
- addition of a halogen or hydrogen to a straight chain alkene/alkyne,
- acid elimination (dehydration of alcohol only), and
- esterification.

Teachers should

- inform students that combustion reactions can be complete or incomplete; however, students will be expected to write and balance only complete combustion reactions;
- inform students that many of these reactions require the use of catalysts (and/or heat); however, these do not need to be included in specific reactions;
- limit cracking and reforming examples by providing names and/or structures for products and reactants; and
- limit organic compounds involved in these reactions to a maximum of five carbons in a compound.

Sample Performance Indicators

1. Write balanced chemical equations for the
 - addition of hydrogen to pent-2-ene,
 - cracking of 2,3-dimethylhexane into butane,
 - elimination of a butan-2-ol to produce two isomers,
 - esterification reaction to produce ethylpropanoate,
 - reforming of methane into hexane, and
 - substitution of an alkane to produce 2-chloropropane.
2. Predict the missing products and draw the structural formula for the organic product below:



3. Determine the type of reaction that is illustrated:
 - $\text{CH}_3\text{OH}(\text{aq}) + \text{CH}_3\text{CO}_2\text{H}(\text{aq}) \rightarrow \text{CH}_3\text{CO}_2\text{CH}_3(\text{aq}) + \text{H}_2\text{O}(\text{l})$
 - decane \rightarrow octane + ethene
 - $\text{C}_3\text{H}_8 + \text{C}_4\text{H}_{10} \rightarrow \text{C}_7\text{H}_{14} + \text{H}_2$

Writing and Balancing Organic Chemical Reactions

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Review the functional groups of carboxylic acids, alcohols, and esters, and discuss how to identify the functional groups within these compounds.

Students may

- Draw carboxylic acids and alcohols which could possibly be used to synthesize an ester.

Connection

Teachers may

- Provide examples of organic reactions in nature (such as the production of starch from glucose).

Students may

- Brainstorm other organic reactions from nature. Share and discuss with the class.

Consolidation

Teachers may

- Demonstrate an esterification investigation by preparing an ester from a carboxylic acid and an alcohol. Discuss choices with students prior to demonstration, noting which carboxylic acid and alcohol combinations are used since many of the common carboxylic acids available have a pungent odour. Upon completion of the demonstration, ask students to discuss other possible acid-alcohol combinations to synthesize an ester. Caution must be taken when handling the reaction mixture.

Students may

- Research (once possible carboxylic acid(s) and alcohol(s) have been proposed) the MSDS of the above chemicals to determine if there are any limitations for using the chemical in a lab setting (e.g., butyric acid, which will react to form a scented ester, is itself an extremely pungent chemical).

Extension

Students may

- Research compounds which are used as artificial scents, and investigate whether the compound is an ester. Derive the structures of the carboxylic acid and alcohols which were used to synthesize this compound.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 54, 128-144

Chemistry: Newfoundland and Labrador (SR)

- pp. 322-323, 327-328, 340-341, 353

Technological Connections to Organic Chemistry

Outcomes

Students will be expected to

75.0 describe and evaluate the design of technological solutions, and the way they function using scientific principles
[GCO 1]

76.0 analyze natural and technological systems to interpret and explain their structure and dynamics
[GCO 1]

62.0 *analyze from a variety of perspectives the risks and benefits to society and the environment of applying scientific knowledge or introducing a particular technology*
[GCO 1]

77.0 identify various constraints that result in the trade-offs during the development and improvement of technologies
[GCO 1]

Focus for Learning

Students should examine how the oil refining process extensively uses cracking and reforming reactions to create useful organic compounds from a crude oil mixture of hydrocarbons. They should establish that if there are a series of compounds formed by a cracking (or reforming) process, the compounds are separated using an industrial scale fractional distillation process.

This topic reinforces the cracking and reforming reactions studied earlier in this unit. Teachers may choose to discuss these reactions at this time, as the industrial process of oil refining is also studied.

Teachers should also consider sharing an online video demonstrating a fractional distillation activity (it is not recommended that teachers attempt to demonstrate this process).

Students should discuss the risk-benefit analysis of industries such as oil refining in their communities. Factors to consider include employment provided by the construction and long-term operation of such large scale industrial facilities as well as the environmental effects of the operation of such facilities.

Attitude

Encourage students to

- have a sense of personal and shared responsibility for maintaining a sustainable environment;
- want to take action for maintaining a sustainable environment; and
- confidently evaluate evidence and consider alternate perspectives, ideas, and explanations. [GCO 4]

Sample Performance Indicator

Develop a question based on an industry that has environmental and societal impacts. Research the answer. Share results using a graphic or multimedia format.

Suggested topics:

- Hydraulic Fracturing (Fracking)
- Oil Spills (Deepwater Horizon)
- Transportation (Keystone Pipeline, Northern Gateway Project, Exxon Valdez)

Technological Connections to Organic Chemistry

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Share a video to demonstrate fractional distillation.
- Discuss the role of cracking and reforming in the petrochemical industry.

Students may

- Write jot notes on their observations of the fractional distillation demonstration video. Discuss.

Connection

Students may

- List and analyze the general steps necessary in the refining of petroleum in order to obtain gasoline and a variety of other products.
- Use inquiry to identify a well known refinery (e.g., North Atlantic Refinery at Come By Chance) and determine compounds which are cracked and/or reformed during their refining process. Present results with balanced chemical reactions.

Consolidation

Students may

- Generate an example of a scientific question or technological problem which applies to organic chemistry. Trade with another student and discuss answers to the question or problem.

Extension

Students may

- Research fractional distillation in greater depth to include answers to the following questions:
 - Historically, how was fractional distillation first implemented in oil refining?
 - How are yields optimized?
 - What is the potential for isomeric products and is it possible to increase the yield of one isomer over the other?

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (SR)

- pp. 320-322

Suggested

Resource Links: <https://bit.ly/2q0GY06>

- Fractional Distillation (video)
- Naming Derivatives (video)

Polymer Chemistry

Outcomes

Students will be expected to

78.0 describe processes of polymerization and identify some important natural and synthetic polymers [GCO 3]

72.0 provide examples of how science and technology are an integral part of their lives and their community [GCO 1]

79.0 distinguish between scientific questions and technological problems [GCO 1]

Focus for Learning

Students should be able to identify and discuss many items that contain polymers. A visible collection of items containing polymers would be helpful to students during discussion. Some of these may include a Teflon™ frying pan, vinyl household siding or PVC pipe, plastic shopping bags, reusable and non-reusable plastic water bottles, nylon and polyester fabrics, silk, wool, DNA, wood, food.

Students should be able to compare a monomer to a polymer. They should then be able to describe how the repeating unit of a polymer is derived from hundreds or thousands of monomers.

It is not expected that students build models showing polymerization. They should write complete polymerization reactions and be able to identify and recognize the difference between addition and condensation polymers. As well, students should be able to draw the monomer reactant when given a polymer.

Students should understand and be able to discuss differences between science and engineering as they relate to circumstances within their own lives. They should be able to propose solutions to problems that are connected to their own lives. For example, while many polymer plastics are recyclable, devising a practical recycling program in a municipality is often challenging; while research is necessary, disposing of contaminated samples is problematic.

Attitude

Encourage students to

- be aware of the direct and indirect consequences of their actions, and
- project the personal, social, and environmental consequences of proposed action. [GCO 4]

Sample Performance Indicators

1. Describe the relationship between the terms monomer and polymer. What are the names of the two types of polymerization reactions?
2. Create a chart to compare recycling programs in your area to those in other parts of the province. Consider the types of plastics and other materials that are being recycled. Offer solutions to recycling deficiencies in your area.

Polymer Chemistry

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Introduce the topic of polymers by gathering a list of items containing polymers such as Teflon™ frying pan, vinyl household siding or PVC pipe, plastic shopping bags, reusable and non-reusable plastic water bottles, nylon and polyester fabrics.

Students may

- Complete a polymer making activity using the steps below:
 1. Place 20 mL of glue in a beaker and add 40 mL of water (with two drops of food colouring).
 2. Add 8 g of borax and stir.
 3. Once thickened, remove from beaker and record observations (e.g., ability to be pulled apart, bounce, flow).
 4. Compare properties of the original materials with properties of the resulting polymer.

Connection

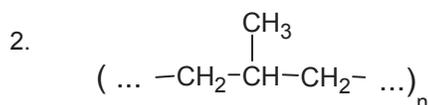
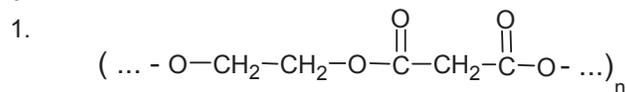
Students may

- Write an account of the items they use or have contact with in a single day that includes polymers. Answer: Are polymers important? Why or why not?
- Design an experiment to prepare soap or to prepare acetylsalicylic acid. This can be an organizational activity to help plan (not to complete) the lab.

Consolidation

Students may

- Determine the monomer which would yield the following polymers:



Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 146-155

Chemistry: Newfoundland and Labrador (SR)

- pp. 372-398

Properties of Addition Polymers

Outcomes

Students will be expected to

- 1.0 define and delimit problems to facilitate investigation [GCO 2]
- 2.0 *design an experiment identifying and controlling major variables* [GCO 2]
- 12.0 *select and use apparatus and materials safely* [GCO 2]
- 13.0 *demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials* [GCO 2]
- 80.0 evaluate the design of a technology and the way it functions, on the basis of a variety of criteria that they have identified themselves [GCO 1]

Focus for Learning

Students should design and complete a lab investigation on the properties of common addition polymers (plastics).



Given six common plastics (1 cm²) listed below, as unknowns, students should design an investigation to identify each based on

- Density – Students can place each sample of plastic in a variety of liquids with known density (e.g., water-1.00 g/mL, glycerol-1.26 g/mL, rubbing alcohol-0.79 g/mL).
- Combustion (suggestion: teachers demonstrate in a fume hood) – All plastics will burn while held in a flame:
 - PVC will stop burning when taken out of a flame.
 - LDPE will drip when burned.
 - PS produces black soot when burned.
 - HDPE, PP, and PETE burn with a common flame and little smoke.

Recycle # (plastic type)	Abbreviation	Name	Density* g/mL	Common Use
1	PETE	polyethylene terephthalate	1.38	soda bottles
2	HDPE	high density polyethylene	0.96	detergent bottles
3	PVC	polyvinyl chloride	1.24	plumbing pipe
4	LDPE	low density polyethylene	0.93	plastic bags
5	PP	polypropylene	0.90	margarine container
6	PS	polystyrene	1.05	packing material

*Approximate and may vary slightly

Once complete, they should be able to evaluate the design of the plastics and their functions in relation to practical usage and durability of each.

For elaboration on outcomes 1.0, 2.0, 12.0, and 13.0, refer to the Integrated Skills unit. Teachers may also wish to address and assess additional skill outcomes (e.g., SCO 16.0).

Attitude

Encourage students to

- show concern for their safety and accept the need for rules and regulations, and
- work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas. [GCO 4]

Properties of Addition Polymers

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Review previously addressed proper safety procedures when conducting lab investigations.

Students may

- Name one plastic product they use regularly. What changes could you make that would help reduce plastic waste?

Connection

Students may

- Determine
 - the types of plastics that are recyclable locally, provincially, and nationally;
 - why there are differences between communities in NL and between provinces in Canada; and
 - ways to improve efforts locally and provincially.
- Discuss how manufacturers of products can help reduce plastic waste.

Consolidation

Students may

- Determine how the different types of plastics are sorted for recycling. Create a table to list the number and acronym given to a particular type of plastic. Record its name and list examples of products in the community.

Plastic	Name of Plastic	Used in Products
1. PETE	polyethylene terephthalate	soft drink bottles, food jars
2.		
3.		

Extension

Students may

- Find information on degradable plastics:
 - What are their advantages over synthetic plastics?
 - What are biodegradable and photo-degradable plastics?

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 128-144, 146-155

Chemistry: Newfoundland and Labrador (SR)

- p. 399

*Organic Chemistry and Society***Outcomes**

Students will be expected to

11.0 *select and integrate information from various print and electronic sources or from several parts of the same source*
[GCO 2]

18.0 identify and apply criteria, including the presence of bias, for evaluating evidence and sources of information
[GCO 2]

19.0 *provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion*
[GCO 2]

24.0 synthesize information from multiple sources or from complex and lengthy texts and make inferences based on this information
[GCO 2]

25.0 develop, present and defend a position or course of action, based on findings
[GCO 2]

Focus for Learning

Students should be cognizant of today's world of rapid technological development in which the concepts of organic chemistry are being applied within their lives. They should have a variety of opportunities to investigate the implication of organic chemistry in their everyday lives.

For elaboration on outcomes in column one, refer to the Integrated Skills unit.

Attitude

Encourage students to acquire, with interest and confidence, additional science knowledge and skills, using a variety of resources and methods, including formal research. [GCO 4]

Sample Performance Indicator

Answer the following questions:

1. What is bias? Why is it important to be aware of bias when completing research?
2. What is an example of a reliable resource that can be used when researching degradable plastics?
3. Summarize the risks and benefits of using plastics in our everyday lives (consider environmental, economic, health factors etc.).
4. In your opinion, should plastic use be phased out and an alternative be enforced?
5. Should government be involved in collecting recycling fees for plastics (i.e., similar to fees collected for aluminum cans)? Discuss.

Organic Chemistry and Society

Sample Teaching and Assessment Strategies

Activation

Teachers may

- Use a variety of current topics to stimulate student interest and discussion (e.g., cosmetics, perfume, lotion, food and food additives, plastics, paper, insect repellent, synthetic fabrics, soaps, detergents, pesticides, paint, vitamins).

Students may

- Use websites such as Curiosity™ to find engaging topics for discussion (e.g., concentrations of carbon dioxide, facts about biofuels). Share quick facts with the class.

Connection

Teachers may

- Share a video that outlines some of the problems our society faces as a result of our use of plastics (e.g., great Pacific garbage patch).

Students may

- Describe environmental health problems associated with the use of polymers.
- Choose one relevant topic and create an infographic or public service announcement (PSA) to outline its implications. Alternatively, a comparison may be made to past and future.

Consolidation

Students may

- Prepare a monologue (or written report) to detail how they personally use organic chemistry every day.
- Participate in a panel discussion where the following questions and/or problems provide the focus:
 - How are PCB's converted into dioxins?
 - How do we dispose of contaminated samples from organic waste?
 - How does oil collected from the oil sands differ from oil extracted from underground deposits?
 - How does the oil extracted from the oil sands safely travel to the refineries and then to consumers?
 - Explore hydraulic fracking as it relates to health, economics, and the environment.

Resources and Notes

Authorized

Chemistry: Newfoundland and Labrador (TR)

- pp. 146-155

Chemistry: Newfoundland and Labrador (SR)

- pp. 390-392

Appendix A: Scientific Conventions

Scientific Conventions

Scientific information should be communicated according to accepted scientific conventions. These conventions include significant figures, formulas, units, and data (graphs, diagrams, tables). The Department of Education and Early Childhood Development follows the conventions below for public exams.

Significant Figures

Any number used in a calculation should contain only figures that are considered reliable; otherwise, time and effort are wasted. Figures that are considered reliable are called significant figures. Scientific calculations generally involve numbers representing actual measurements. In a measurement, significant figures in a number consist of:

Figures (digits) definitely known + one estimated figure (digit)

They are often expressed as “all of the digits known for certain plus one that is uncertain”.

Significant Figure Rules

1. All non-zero digits are significant.
2. Zero rules
 - Trailing zeros (i.e., at the end to the right) of a measurement may or may not be significant:
 - If it represents a measured quantity, it is significant (e.g., 25.0 cm - the zero is significant; the decimal is clearly indicated).
 - If immediately to the left of the decimal, it is not significant (e.g., 250 cm or 2500 cm - zeros are not significant; both have 2 significant digits as there is uncertainty whether zeros are measured values).
 - If the trailing zeros in 250 cm and 2500 cm are significant, the measurements must be written in scientific notation (e.g., 2.50×10^2 cm or 2.500×10^3 cm - zeros are significant).
Note: Scientific notation is not part of the K-12 mathematics program.
 - A zero, between two non-zero digits in a measurement, is significant (e.g., 9.04 cm - the zero is significant).
 - Leading zeros (i.e., at the beginning to the left) are never significant (i.e., they do not represent a measured quantity), they merely locate the decimal point (e.g., 0.46 cm and 0.07 kg - the zeros are not significant).

3. Rounding with Significant Figures

In reporting a calculated measured quantity, rounding an answer to the correct number of significant figures is important if the calculated measurement is to have any meaning. The rules for rounding are listed below.

- If the figure to be dropped is less than 5, eliminate it:
 - rounding 39.949 L to three significant figures results in 39.9 L
 - rounding 40.0 g to two significant figures results in 4.0×10^1 g
- If the figure to be dropped is greater than or equal to 5, eliminate it and raise the preceding figure by 1:
 - rounding 39.949 L to four significant figures results in 39.95 L
 - rounding 39.949 L to two significant figures results in 4.0×10^1 L

4. Multiplying and Dividing with Significant Figures

In determining the number of significant figures in a measurement that is calculated by multiplying or dividing, the measurement with the least number of significant figures should be identified. The final calculated measurement should contain the same number of significant figures as the measurement with the least number of significant figures.

$$2.1 \text{ cm} \times 3.24 \text{ cm} = 6.8 \text{ cm}^2$$

Since 2.1 cm contains two significant figures and 3.24 contains three significant figures, the calculated measurement should contain no more than two significant figures.

5. Adding and Subtracting with Significant Figures

In determining the number of significant figures when adding or subtracting, the final calculation should be rounded to the same precision as the least precise measurement.

$$42.56 \text{ g} + 39.460 \text{ g} + 4.1 \text{ g} = 86.1 \text{ g}$$

Since 4.1 g has only one decimal place, the calculated measurement must be rounded to one decimal place.

6. Performing a Series of Calculations with Mixed Operations

When a series of calculations is performed, it is important to remember that multiplication/division and addition/subtraction are governed by separate significant figure rules. Rounding only occurs at the last step.

When calculations involve both of these types of operations, the rules must be followed in the same order as the operations. Rounding still only occurs at the last step of the calculation.

$$\frac{(0.428 + 0.0804)}{0.009800}$$

The addition is first, $0.428 + 0.0804 = 0.5084$. Following the rules for addition/subtraction, the answer should have three significant figures, but rounding is the last step. Therefore, 0.5084 is used in the next step, $0.5084 \div 0.009800 = 51.87755$. Following the rules for multiplication/division, the answer should have four significant figures (but rounding is the last step). The sum of the numerator has three significant figures, and the denominator has four, so the final answer is rounded to three significant figures, 51.9.

In problems requiring multiple calculations (e.g., calculating final velocity and then using that value to calculate time), it is recommended that rounding only occur in the final calculation. Also, to improve accuracy and consistency, an extra digit should be carried in all intermediate calculations. Students may find it helpful to write the extra digit as a subscript (e.g., 39.5_4 [3 significant figures + 1 extra]).

7. Calculating with Exact Numbers

Sometimes numbers used in a calculation are exact rather than approximate. This is true when using defined quantities, including many conversion factors, and when using pure numbers. Pure or defined numbers do not affect the accuracy of a calculation. You may think of them as having an infinite number of significant figures. Calculating with exact numbers is important when dealing with conversions or calculating molar ratios in chemistry.

8. Scientific Constants

Treat scientific constants as significant digits because they are rounded values (i.e., actual measured or defined values have many decimal places [e.g., the speed of light constant, 3.00×10^8 m/s, is a rounded value based on the defined value, 299 792 458 m/s]).

9. Significant Figures in Logarithms

When determining the number of significant figures from a logarithm function, only the digits to the right of the decimal should be counted as significant figures.

- What is the pH of a sample of orange juice that has 2.5×10^{-4} mol/L hydronium ions?
The measurement 2.5×10^{-4} mol/L has two significant figures. The power of ten indicates where the decimal is located (i.e. 0.00025). The pH of the sample is $-\log(2.5 \times 10^{-4}) = 3.602\ 059$. The digit to the left of the decimal is derived from the power of ten, therefore, it is not significant. Only two digits to the right of the decimal are significant. The answer should be recorded as 3.60.
- What is the hydronium ion concentration of orange juice with pH = 2.25?
The pH value, 2.25, has two significant figures. The hydronium ion concentration is equal to the antilogs of -2.25. This value is 0.0056234 mol/L, which, when rounded to two significant figures, becomes 0.0056 mol/L or 5.6×10^{-3} mol/L.

Formulas and Units

A constructed response question that requires numerical calculations often uses formulas or equations as the starting point to its solution. Proper use of formulas and units in science indicates a thorough understanding of the logic to solve a problem. For any solution that requires the mathematical manipulation of a formula, the formula should be stated at the beginning, followed by workings that clearly indicate the mathematical computations necessary to find the solution.

For most cases in science, a SI unit follows a measured value because it describes the value. Three exceptions to this are pH, equilibrium constants, and index of refraction. The final answer of a solution for a constructed response question that requires the mathematical manipulation of a formula always has a unit with the value. The workings of a solution that lead to the final answer do not have to show units.

Data

Data is generally presented in the form of graphs, tables, and drawings. When these formats are used several scientific conventions should be followed.

Graphs

Graphs represent relationships between numerical information in a pictorial form. Two kinds of graphs are commonly used in science courses in Newfoundland and Labrador:

- Line graph
 - used to display the relationship between continuous data
 - demonstrates a progression of values or shows how one variable changes in relation to another variable (e.g., growth of a child with age)

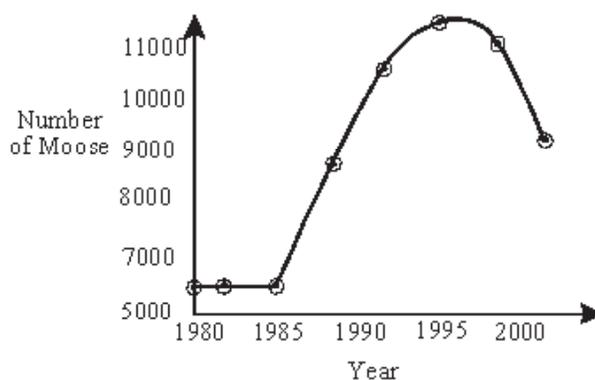
Note: When equations are graphed, a line or curve of best-fit must be drawn.

- Bar graph
 - used to display discrete or discontinuous data
 - consists of parallel bars whose lengths are proportional to quantities given in a set of data. The items compared are plotted along the horizontal axis and appropriate measurement is plotted along the vertical axis (e.g., populations of different types of protists in a lake).

Graphing Rules:

1. The graph must have a title. The title represents the relationship between the two variables.
2. The independent variable is on the horizontal x-axis.
3. The dependent variable is on the vertical y-axis.
4. Each axis is specifically labelled with units (if applicable) according to the variable it represents and values are provided with equal increments. The scale does not have to be the same on both axes, but the scales must accommodate the ranges of the two variables (i.e., the graph line or series of bars must fill $\geq 75\%$ of the available space).
Note: It is not necessary that both axes start at zero. See example below.
5. When data are plotted, a circle should be placed around each point to indicate a degree of error. The graph may show exact numbers or a general relationship. A best-fit line or curve must be used in line and scatter graphs.
6. A legend may be used to identify individual lines on a multi-line graph.

Moose Population in Newfoundland and Labrador (1980 - 2000)

**Tables**

Tables represent numerical or textual information in an organized format. They show how different variables are related to one another by clearly labelling data in a horizontal or vertical format. As with graphs, tables must have a title that represents the relationship between the variables.

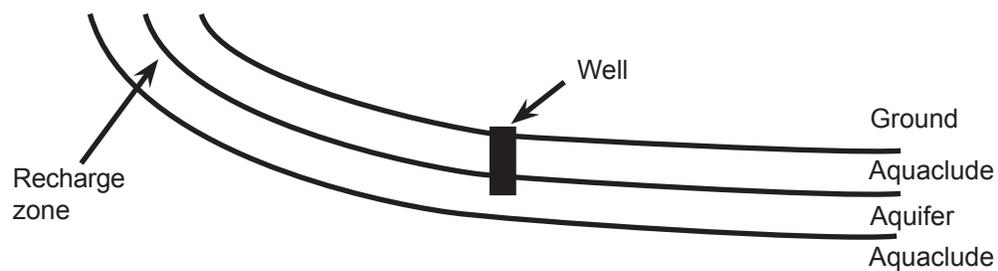
Moose Populations in Newfoundland and Labrador (1980 - 2000)

Year	Number of Moose
1980	5789
1985	6057
1990	8823
1995	11 156
2000	9315

Drawings

Biological drawings that indicate a scale are not required. Diagrams, however, may often be used to aid explanations. These should be clear and properly labelled to indicate important aspects of the diagram.

Geological Conditions Necessary for an Artesian Well



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