Department of Education and Early Childhood Development

Chemistry 111/112

Prioritized Curriculum | Published May 2020

New Nouveau Brunswick CANADA

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The outcomes included in this document were exported from the original source document published by the Government of New Brunswick (2009). Chemistry 111/112 Curriculum. Access curriculum document here.

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Background and Rationale

Due to the reduced learning time presented by school closures for COVID-19 and the uncertainty of what the 2020-2021 year will bring, the Department of Education and Early Childhood Development (EECD) is releasing a prioritized curriculum for select high school courses. This document provides a list of required outcomes that will frame the learning expectations for students and offer time for effective teaching practices.

A team of New Brunswick chemistry, mathematics and physics educators – high school teachers, post-secondary instructors from New Brunswick Community College and University of New Brunswick and Learning Specialists from EECD worked together to identify and curate a list of **Required Outcomes** for the 2020-2021 school year. Any outcomes that were not identified as being *required* were categorised as **Remaining Outcomes** and can be set aside for future learning.

The *Required Outcomes* outlined in this document have been identified as the best representation of instructional outcomes to engage learners and contribute to student readiness for post-secondary mathematics and science studies and/or future life pursuits.

Identification of the *Required Outcomes* is but one of the necessary elements which will support learners in the province. Teachers will also consider how to engage students in deep and meaningful ways within the framework of the new learning environments (online, blended, and/or face-to-face).

Required Outcomes

The outcomes presented in Units 1 and 2 frame the learning expectations for students for the 2020-2021 academic year. Read this document carefully as some outcomes have been reassigned or categorised as remaining (not required).

UNIT 1: From Structures to Properties

Learner readiness for Chemistry 11.
Due to the school closures, teachers will be required to address knowledge gaps of introductory chemistry concepts and skills. The subject matter of Unit 1 includes theories, models, concepts, and principles (Science 10) that are essential for understanding and applying knowledge not only for Chemistry 111/112 but also Chemistry 121/122.

Topic: Elements and Compounds

- Define and differentiate between ionic and molecular compounds, including acids and bases, using conductivity and indicators. (212-8, 319-2 (I))
- Identify, name and write formulas for ionic (binary, multivalent, polyatomic, and hydrates) and molecular compounds, and acids using IUPAC and classical systems. (319-1(I), 319-1 (II), 319-2, 114-8-review)

Topic: Chemical Bonding (*New to this section*)

- *Demonstrate and understanding of periodicity of Ionization Energy, electronegativity and atomic radii. (Level 1 only)*
- Illustrate and explain the formation of ionic, covalent, and **metallic bonds**. (321-4b) Define valence electrons, electronegativity, ionic, **metallic bond**, **nonpolar covalent and polar covalent** bond.
- Identify lone pairs, bonding electrons, deduce bonding capacity, sketch Lewis Dot structures and structural diagrams.
- Identify limitations of categorizing bond types based on differences in electronegativity between the elements and compounds. (214-2)
- Investigate covalent network solids with reference to the **allotropes of carbon** (diamond, graphite, *graphene,* fullerenes, Bucky ball, nanotubes).
- Use **digital** (electronic) **research tools** to collect bonding information. (213-6)
- Select and integrate information from various print and electronic sources. (213-7**)**
- Identify coordinate covalent bonds in ozone, carbon monoxide and various polyatomic ions. (Level 1 only)
- Examine exceptions to the octet rule (Level 1 only)

Examine resonance structures. (Level 1 only)

Topic: Molecular Shape - VSEPR Theory

A memory aid / reference sheet for identifying the shapes recommended.

- Explain the structural model of a substance in terms of the various bonds that define it. (321-11)
- Draw the *three-dimensional* VSEPR diagram and name the shapes of various molecules. (321-11)
- Explain the hybridization of atomic orbitals of the central atom to produce molecular orbitals with the correct observed molecular geometry. (Level 1 only)
- Describe the shapes of molecules based on five (trigonal bipyramidal) and six domains (octahedral) of electrons around the central atom e.g. SF6 or PCI5. (Level 1 only - Optional)

Topic: Intermolecular Forces

- Illustrate and explain hydrogen bonds, van der Waals? forces (dispersion forces), and dipole-dipole forces. (321-5)
- Identify types of intermolecular forces between molecules in a substance. (321-11)
- Compare the strength of van der Waals forces, dipole-dipole forces, and hydrogen bonding. (321-5)

Topic: Properties

- Identify and describe the properties of ionic, molecular, **metallic** and covalent network substances. (321-7)
- Classify ionic, molecular, **metallic** and covalent network substances according to their properties. (321-9)
- Describe how the different types of bonds account for the properties of ionic, molecular, **metallic** and covalent network substances. (321-8)

The importance of mathematics for Chemistry learning.
An appropriate background in mathematics is needed to succeed in high school chemistry. Students are expected to transfer and apply math skills to solve chemical calculations and perform the mathematical formulation of principles in Chemistry 11.

UNIT 2: Stoichiometry

Topic Chemical Changes

- Predict products of chemical reactions. (321-1)
- Identify the five types of chemical reactions: formation, decomposition, combustion, single, and double replacement including precipitation, neutralization. (321-1, 321-2)
- Write balanced chemical equations for the five different types of chemical reactions: formation, decomposition, combustion, single, and double replacement. (321-1)
- Predict the states of the products to identify gases produced, solids as in precipitates etc.

Topic: The Mole and Balancing Equations

- Define the Mole in terms of the number of atoms in exactly 12 g of carbon-12 (Avogadro's number of particles). (323-1)
- Demonstrate the proper use of SI units and significant digits in all computations.
- Convert number of particles to mass and moles. (Level 1 only)
- Explain how a major scientific milestone, the mole, changed chemistry. (115-3) (Level 1 only)

Topic: Molar Mass (*Includes outcomes previously in Stoichiometric Calculations and Gas Laws and Stoichiometry*)

- Define molar mass and determine the molar mass of an element and compound. (323-1)
- Define molar volume @STP for gases.
- Perform mole-mass inter-conversions and mole-mass-volume inter-conversions for gases. (323-1)
- Calculate the percent composition from a compound's formula. (323-1)
- Calculate molecular formula from percent composition and molar mass. (323-1)
- Convert between the Celsius and Kelvin temperature scales and express atmospheric pressure in a variety of ways, including mm of Hg, torr, atm, kPa
- Explain Avogadro's law and molar volume.
- Determine molar volume under constant conditions, using molar ratio in balanced chemical equation.

Topic: Mole Ratio Calculations

- Identify mole ratios of reactants and products from balanced chemical equations. (323-10)
- Perform calculations using mole-to-mole stoichiometric problems.
- Perform stoichiometric calculations related to chemical equations. (323-11)
- State a prediction and a hypothesis based on available evidence and background information. (212-4)
- Identify practical problems that involve technology where equations were used. (214-13)

Topic: Limiting Reagents (Conceptual understanding only)

- Explain the concept of limiting reagent.

Laboratory investigations in virtual environments.
Teachers are encouraged to conduct and record investigations, use interactive simulations, and/or YouTube video demonstrations (that they have previously reviewed) to introduce learners to laboratory techniques and procedures for Chemistry.

Topic: Stoichiometric Experimentation (*Requires customization depending on pedagogical approach*)

- *Design stoichiometric experiments identifying and controlling major variables.* (212-3)
- Predict how the yield of a particular chemical process can be maximized. (323-13)
- *Use instruments effectively* and accurately for collecting data. (213-3)
- *Select and use apparatus and materials safely. (213-8)*
- Identify and explain sources of error and uncertainty in measurement using precision and accuracy. (214-10)
- Communicate questions, ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others. (215-1)

Topic: Applications of Stoichiometry

- Identify various stoichiometric applications. (323-12)
- Communicate questions, ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others. (215-1)
- Compare processes used in science with those used in technology. (114-7)
- Analyse society's influence on science and technology. (117-2)
- Identify various constraints that result in trade-offs during the development and improvement of technologies. (114-4)

Topic: Gas Law and Stoichiometry

- Convert between the Celsius and Kelvin temperature scales and express atmospheric pressure in a variety of ways, including mm of Hg, torr, atm, kPa
- Explain Avogadro's law and molar volume.
- Determine molar volume under constant conditions, using molar ratio in balanced chemical equation.

Appendix A - Remaining Outcomes

Remaining outcomes can be set aside for future learning.

UNIT: From Structures to Properties

Topic: The Underlying Structure of Matter

- Describe the energies and positions of electrons according to the quantum mechanical model.
- Describe how the shapes of orbitals differ as it relates to different sublevels.
- Write electron configuration diagrams using Hund's rule, Pauli exclusion principle and Aufbau principle (diagonal rule).
- Demonstrate an introductory understanding of the Quantum Mechanical Model. (Level 1 only)

Topic Chemical Changes

- Compare and contrast physical, chemical, and nuclear changes (in terms of the bonds broken and magnitude of energy changes involved).
- Investigate Kinetic Molecular Theory (KMT).
- Investigate Collision Reaction Theory.
- Identify empirical evidence that may indicate that a chemical change has occurred.
- Differentiate between endothermic and exothermic changes.
- states of the products to identify gases produced, solids as in precipitates etc.
- Analyse, from a variety of perspectives, the risks and benefits to society and the environment of applying bonding knowledge or introducing a technology. (118-2)
- Explain how bonding theory evolved as new evidence and theories were tested and subsequently revised or replaced. (114-2, 115-7)

Topic: Chemical Bonding

- Investigate current and possible uses of carbon nanotubes such as nanotechnology. (Level 1 only - optional)

Topic: Intermolecular Forces

- Analyse, from a variety of perspectives, the risks and benefits to society and the environment of applying bonding knowledge or introducing a particular technology. (118-2)
- Explain how bonding theory evolved as new evidence and theories were tested and subsequently revised or replaced. (114-2, 115-7)
- Analyse and describe examples where technologies were developed based on bonding. (116-4

UNIT: Stoichiometry

Topic: Mole Ratio Calculations (Ideally addressed in laboratory setting)

- *Use instruments* effectively and accurately for collecting data. (213-3)
- *Select and use apparatus and materials safely*. (213-8)

Topic: Solutions

- Compile and organize solution data, using appropriate formats and data treatments to facilitate interpretation of solubility. (213-5)
- Explain solubility, using the concept of equilibrium. (323-4)
- Identify different types of solutions (acids, bases, neutral, ionic and molecular) and their properties (conductivity, pH, solubility).
- Identify dissociation and ionization equations.
- Use the solubility generalizations to predict the formation of precipitates. (323-8)
- *Conduct a precipitate lab* and include recording, observing and collecting data, writing ionic and net ionic equations, and analyzing results.

Topic: Solubility Curves (Level 1 only)

- *Perform a lab* involving solubility curves. (Plot the solubility and average temperature data; Calculate solubility and perform calculations involving solubility).
- Identify and explain sources of error and uncertainty. (214-10)

Topic: Solution Concentration

- Determine the molar solubility of a pure substance in water. (322-6)
- Identify and describe science-and technology-based careers related to solutions and equilibrium. (117-7)
- Differentiate between molarity and molality. (Level 1 only)
- Demonstrate an understanding of colligative properties. (Level 1 only)

Topic: Solubility

- Explain the variations in the solubility of various pure substances, given the same solvent. (323-7)

Topic: *Gas Law* and Stoichiometry (Outcomes related to gases)

- Describe the behavior of *ideal and real gases* in terms of the kinetic molecular theory.
- Define STP and SATP and the molar volume of *an ideal gas* at STP and SATP.
- Perform stoichiometric calculations based on *the ideal gas* equation, PV = nRT, under a variety of conditions, e.g., standard temperature and pressure (STP), standard ambient temperature and pressure (SATP).

UNIT: Research Project

Topic: Chemistry Research (Level 1 only)

Appendix B - Enablers

Pre-requisite knowledge, skills, and experiences required by learners that facilitate learning of the discipline (subject) at the next level. Awareness of enablers allows teachers to optimise pedagogy and students their learning.

General

Math concepts

- Calculating percentages
- Graphical representation of data
- Units and their "behavior" in calculations (ex. 2 m x 2 m = 4 m^2).
- Rearranging equations
- Significant figures
- Scientific notation

Science concepts

- Difference between accuracy and precision
- Converting measurements from one unit to another (including compound units)
- Dimensional (unit) analysis

Competencies

- Higher order thinking skills; synthesizing, analyzing, application and problem-solving
- Developing scientific reasoning

Subject specific

The outcomes listed in Unit 1 are prescribed learning for grades 9 and 10. They represent conceptual and procedural knowledge for introductory chemistry concepts for Science 9 (Atoms and Elements) and Grade 10 (Chemical Reactions). Also, some of this content was covered in the middle school Unit - Pure Substances and Mixtures.

Unit 1: From Structure to Properties

Topic: Classification of Matter

- Define and classify matter according to its composition (pure substances or mixtures).
- Define and distinguish between, chemical and physical properties.
- Define and classify matter as elements and compounds, and as heterogeneous mixtures and solutions.
- Use the periodic law as illustrated by the periodic table to identify and distinguish metals and non-metals, periods and groups, representative and transition elements, and families.
- Describe the factors which contribute to the unique position of hydrogen on the periodic table.
- Identify the elements that are most prevalent in living systems.
- Research ingredients and additives in consumer products. (213-7)
- Identify consumer products and investigate the claims made by companies about the products. (212-5)

Topic: The Underlying Structure of Matter

- Use standard atomic notation to represent atoms, define isotope and use iso notation.
- Predict ionic charges from position on the Periodic Table.
- Define atomic mass, explain the relative nature of atomic mass.
- Provide definitions and examples of atoms, ions, and molecules, including subatomic particles, atomic mass, atomic number, mass number, valence electrons, isotopes.
- Identify the inadequacies in the Rutherford and Bohr models.
- Identify the new proposal in the Bohr model of the atom.

Appendix C - Online Learning Resources

Bozeman Chemistry
Description: *Bozeman Chemistry* was created by educator, Paul Andersen. Paul was the 2011 Montana Teacher of the Year and was also one of four finalists for the 2011 National Teacher of the Year. In addition to teaching he has created hundreds of YouTube science tutorials that have been viewed millions of times by students around the world.
Website: http://www.bozemanscience.com/chemistry

Khan Academy's Preparing to Study Chemistry
Description: Chemistry draws on math, physics, and general science skills. See how to prepare yourself for success in chemistry.
Website: https://www.khanacademy.org/science/chemistry
Available in multiple languages.

OpenStax BC – Chemistry
Description: *Chemistr*y, an OpenStax resource has been created with several goals in mind: accessibility, customization, and student engagement—all while encouraging students toward high levels of academic scholarship. Instructors and students alike will find that this textbook offers a strong foundation in chemistry in an accessible format.
Website: https://opentextbc.ca/chemistry/front-matter/preface/

PhET Interactive Simulations
Description: Founded in 2002 by Nobel Laureate Carl Wieman, *the PhET Interactive Simulations* project creates free interactive math and science simulations. PhET sims engage students through an intuitive, game-like environment where students learn through exploration and discovery.
Website: https://phet.colorado.edu/en/simulations/category/chemistry
Available in multiple languages.

The Sourcebook for Teaching Science
Description: *Resources for Teaching Chemistry.* Hands-on chemistry activities with real-life applications contains over 300 intriguing investigations designed to engage students in a genuine pursuit of science.
Website: http://www.csun.edu/science/chemistry/index.html

TED Ed – How to use Ted Ed in your Chemistry classroom
Description: *TED-Ed's* mission is to capture and amplify the voices of great educators around the world. Highland Park High School teacher Gordon Williamson uses TED-Ed Lessons extensively in his chemistry classroom to catalyze conversations and supplement his curriculum. This is a snapshot of his favorite lessons and how he applies them into his teaching practice.
Website: https://blog.ed.ted.com/2015/05/29/how-to-use-ted-ed-in-your-chemistry-classroom/

Waltzing Atoms
Description: Create and post playful chemical exercises (i.e. 3D visualization of molecules and chemical reactions) that the students solve on their smart phones or tablets, get instant feedback how fast your problems are understood - all in one browser app.
Website: https://www.waltzingatoms.com/waltzing-atoms-lab

University of Waterloo Chem13 News – Lessons
Description: The University of Waterloo Department of Chemistry has been publishing *Chem 13 News* magazine for 50 years providing a platform for high school chemistry teachers to share their ideas, successes and resources.
Website: https://uwaterloo.ca/chem13-news-magazine/lessons

The Wonder of Science
In the science classroom a carefully chosen phenomenon can drive student inquiry. Phenomena add relevance to the science classroom showing students science in their own world. The Master List of Phenomenon is an open Google doc that lists a database of aggregated phenomenon. These phenomena will be tagged and added to the website (with relevant links, videos, and images) over time. This website is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.
Website: https://thewonderofscience.com/phenomenal