The Department of Education and Early Childhood Development

Chemistry 121/122

Prioritized Curriculum | Published May 2020

New Nouveau Brunswick CANADA

Acknowledgements

The Department of Education and Early Childhood Development of New Brunswick (EECD) gratefully acknowledges the contributions of the following groups and individuals toward the development of the Chemistry 121/122 prioritized curriculum:

- Kevin Bowes, Teacher, ASD-North
- Vanessa Chamberlain, Teacher, ASD-South
- Heather Roxborough, Online Teacher, ASD-West
- Brent Jewett, Teacher, ASD-West
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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 121-122 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, 2 and 3 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 - Thermochemistry

Topic: Thermochemistry (STSE)

- Analyse why scientific and technological activities take place in a variety of individual and group settings. (117-6)
- Analyse from a variety of perspectives the risks and benefits to society and the environment by applying thermochemistry. (118-2)
- Distinguish between questions that can be answered using thermochemistry and those that cannot, and between problems that can be solved by technology and those that cannot. (118-8)
- Propose courses of action on social issues taking into account an array of perspectives, related to science and technology, including that of sustainability. (118-10)

Topic: Science Decisions Involving Thermochemistry

- Describe the importance of peer review in the development of your knowledge about thermochemistry. (114-5)
- Use library and electronic research tools to collect information on a given topic. (213-6)
- Select and integrate information from various print and electronic sources or from several parts of the same source. (213-7)
- Identify multiple perspectives that influence a science-related decision or issue involving thermochemistry. (215-4)

Science, Technology, Society, and Environment (STSE) and Science Decisions topics should unfold organically in the classroom within lessons, demonstrations, lab investigations, etc. and not treated as discrete and distinct outcomes.

Topic: Enthalpy Changes (1)

- Define endothermic reaction, exothermic reaction, specific heat capacity, enthalpy, bond energy, heat of reaction, and molar enthalpy. (324-2)
- Define thermochemistry and thermodynamics.
- Differentiate between endothermic and exothermic changes.
- Calculations involving heat capacity including heat transfer problems.

Topic: Enthalpy Changes (2)

- Illustrate changes in energy of various chemical reactions, using potential energy diagrams. (324-5) (Identify exothermic and endothermic processes from the sign of ΔH, from thermochemical equations, and from labeled enthalpy/ potential energy diagrams; Label enthalpy diagrams given either the ΔH for a process or a thermochemical equation).
- Compile and display evidence and information on heats of formation in a variety of formats, including diagrams, flow charts, tables, and graphs. (214-3) (Write thermochemical equations including the quantity of energy exchanged given either the value of ΔH or a labeled enthalpy diagram, and vice versa).

Topic: Enthalpy Changes (3)

- Compare the molar enthalpies of several combustion reactions involving organic compounds. (324-7)
- Write and balance chemical equations for combustion reactions of alkanes, including energy amounts. (324-1)
- Calculate and compare the energy involved in chemical reactions. (324-3) (Write thermochemical equations to represent enthalpy notation, Hcomb, ΔHfus, ΔHvap; Calculate the heat gained or lost from a system using the thermochemical equation).
- Calculate and compare the energy involved in changes of state. (324-3) (Calculate the heat gained or lost from a system using the formulas q = mc ΔT and q = n Δ H).

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: Thermochemistry Experimentation (*Requires customization depending on pedagogical approach*)

- *Work cooperatively with team members to develop and carry out thermochemistry experiments*. (215-6)
- *Evaluate and select appropriate instruments* for collecting evidence and appropriate processes for problem solving and inquiring. (212-8)
- *Design a thermochemistry experiment* identifying and controlling major variables. (212-3)
- *Determine experimentally* the changes in energy of various chemical reactions. (324-6)
- Analyse the knowledge and skills acquired in their study of thermochemistry to identify areas of further study related to science and technology. (117-9) (Compare physical, chemical, and nuclear changes in terms of the species and the magnitude of energy changes involved).

- Propose alternative solutions to solving energy problems and identify the potential strengths and weaknesses of each. (214-15) (Explain, in simple terms, the energy changes of bond breaking and bond formation).

Topic: Bonding and Hess's Law

- Calculate the changes in energy of various chemical reactions using bond energy, heats of formation, and Hess's Law. (324-4)
- Apply one of the methods of predicting heats of reactions to your experimentally determined lab values. (214-6) (Conduct a Hess's Law experiment; Compare experimental results to theoretical calculations from heat of formation or bond energy data).
- Analyse and describe examples where technologies were developed based on understanding thermochemistry. (116-4)
- Entropy and Gibbs Free Energy in relation reaction spontaneity. (Level 1 only)

Unit 2: Kinetics and Chemical Equilibrium

Topic: Kinetics and Rate of Reaction

- Identify and discuss the properties and situations in which the rate of reaction is a factor. (321-3) (Identify the factors that affect rate of reaction and how these can be controlled; Perform an experiment to determine the factors that affect the rate of a chemical reaction).

Topic: Collision Theory, Reaction Mechanisms and Catalysts (1)

- Describe collision theory and its connection to factors involved in altering reaction rates (ACC-1) (Explain how various factors can affect the rate of a reaction).

Topic: Collision Theory, Reaction Mechanisms and Catalysts (2)

- Describe a reaction mechanism and catalyst's role in a chemical reaction (ACC-2). (Draw and label a potential energy diagram to show the effect of a catalyst on the rate of a reaction; Define, draw, and label the following on a potential energy diagram for an exothermic and endothermic reaction: activation energy, activated complex, transition state, ΔH, reactants, and products; Define reaction mechanism as a series of elementary reactions; Identify the following components of a reaction mechanism: rate-determining step, reaction intermediates, and catalysts; Write the overall reaction equation from a reaction mechanism).
- Demonstrate an understanding of rate laws with respect to the progress of the reaction. (Level 1 only)
- Write the rate laws given the reaction mechanism or experimental data. (Level 1 only)
- Identify the reaction order. (Level 1 only)

Topic: Chemical Equilibrium (1)

- Compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data. (213-5)
- Define the concept of equilibrium as it pertains to solutions. (323-3)

Topic: Chemical Equilibrium (2)

- Develop and implement appropriate sampling procedures for equilibrium expressions. (213-1, 212-9) (Write equilibrium constant expressions; Predict the favourability of reactant or products in a reversible reaction, on the basis of the magnitude of the equilibrium constant).
- Calculate the solubility product constant (Ksp) and predict precipitation. (Level 1 only)
- Calculation of Equilibrium Constant using the partial pressures of gases (Kp). (Optional)

Topic: Chemical Equilibrium (3)

- Explain how different factors affect solubility, using the concept of equilibrium. (323-5)
- Explain the roles of evidence, theories, and paradigms in Le Châtelier's Principle. (114-2)

Topic: Chemical Equilibrium (4)

- Analyse and describe examples where scientific understanding was enhanced or revised as a result of the invention of a technology. (116-2)
- Analyse and describe examples where technologies were developed based on scientific understanding. (116-4)
- Research the relationship between Le Châtelier's Principle and biological systems (e.g. the bends, blood O_2 levels at high altitudes). (Optional)

Unit 3: Organic Chemistry

Topic: So Many Compounds

- Explain the large number and diversity of organic compounds with reference to the unique nature of the carbon atom. (319-4) (Compare organic and inorganic compounds in terms of the presence of carbon, variety of compounds formed, and relative molecular
- size and mass; Develop an understanding of the historical significance of the name organic chemistry; List natural sources of organic compounds; Represent hydrocarbons using: molecular formula, expanded molecular formula, complete structural diagram, condensed structural diagram, line structural diagram).

Topic: Influences of Organic Compounds on Society

- Analyse natural and technological systems to interpret and explain the influence of organic compounds on society. (116-7)
- Explain how synthesizing organic molecules revolutionized thinking in the scientific community. (115-3)
- Explain how organic chemistry evolves as new evidence comes to light. (115-6)
- Distinguish between scientific questions and technological problems. (115-1)

Topic: Classifying Organic Compounds

- Classify various organic compounds by determining to which families they belong, based on their names or structures. (319-7) (Classify aliphatic hydrocarbons as belonging to the family of alkanes, alkenes, alkynes, and cyclics based on their names and structural formulas; Classify aromatic hydrocarbons as compounds that have a benzene ring as part of their structure; Define "functional group"; Classify hydrocarbon derivatives as belonging to the family of alkyl halides, alcohols, carboxylic acids, and esters from their names and the functional groups in their structural formulas; Draw bonds and use molecular models to represent aliphatic and aromatic hydrocarbons, and hydrocarbon derivatives).
- Include ethers, aldehydes, ketones, amines and amides. (Level 1 only)

Naming and writing organic compounds (I & II) does not need to be covered in depth.
Focus teaching on the following: (a). Properties of functional groups; (b) Recognition of function groups; (c) Real-life examples e.g. in living systems; and (c) Knowing that there are different types.

N.B. The original title, Naming and Writing Organic compounds (I & II) has been modified to reflect the change in focus, Identification of Functional Groups in Hydrocarbon Derivatives (I & II).

Topic: Identification of Functional Groups in Hydrocarbon Derivatives (1)

- Write the formula and provide the IUPAC name for a variety of organic compounds. (319-5) (Name all the prefixes for one to ten carbons in a compound or alkyl group; Define alkyl group; Use the IUPAC naming system, write molecular formulas, and draw structural, condensed structural and line structural formulas for aliphatic hydrocarbons (straight chain , branched chain, and cyclic); Define and give examples of saturated and unsaturated hydrocarbons; Use the IUPAC naming system, write molecular formulas, and draw structural formulas, condensed structural formulas and line structural formulas for simple monosubstituted and disubstituted benzene compounds).

Topic: Identification of Functional Groups in Hydrocarbon Derivatives (2)

- Write the formula and provide the IUPAC name for a variety of organic compounds. (319-5) (Use the IUPAC naming system, write molecular formulas, and draw structural formulas, condensed structural formulas, and line structural formulas for hydrocarbon derivatives belonging to the family of alkyl halides, alcohols, carboxylic acids, and esters limited to only one functional group and a parent chain no longer than 10 carbons).
- Identify limitations of the IUPAC classification system and identify alternative ways of classifying to accommodate anomalies. (214-2)
- Use IUPAC rules for naming ethers, aldehydes, ketones, amines and amides. (Level 1 only)

Topic: Isomers in Organic Chemistry

- Define isomers and illustrate the structural formulas for a variety of organic isomers. (319-6) (Define isomer, structural isomer, and geometric isomer; Explore isomers by drawing structural formulas, using models to build isomers, and naming the isomers of a variety of organic molecules; Draw structural isomers of hydrocarbons with the general formulas CnH2n+2, CnH2n, and CnH2n-2); Draw geometric isomers (cis and trans) for alkenes).
- Identify optical isomers. Discuss their importance in biological systems. (Level 1 only)

Topic: Applications of Organic Chemistry (1)

- Provide a statement that describes the relationship between bonding and organic chemistry investigated in light of the link between data and the conclusion. (214-11) (Explain the trend in boiling point in relation to the number of Carbon in, and branching of, the hydrocarbon chain).
- Provide organic examples of how science and technology are an integral part of their lives and their community. (117-5) (Describe fractional distillation in relation to refining of petroleum; Describe, in general, the processes of cracking and reforming).

Topic: Applications of Organic Chemistry (2)

- Identify various constraints that result in trade-offs during the development and improvement of technologies. (114-4)
- Evaluate the design of a technology and the way it functions, on the basis of a variety of criteria that they have identified themselves. (118-4)

- Identify and apply criteria, including the presence of bias, for evaluating evidence and sources of information on an organic topic. (214-9)

About Organic reactions and polymerization.

Gently introduce the organic reactions, including the nature of polymerization to enhance student understanding of topics within industry and biological sciences.

Topic: Writing and Balancing Chemical Equations

- Write and balance chemical equations to predict the reactions of selected organic compounds. (319-8) (Draw structural diagrams of all organic reactants and products involved in: i. Addition (alkenes & alkynes); ii. Substitution (alkanes & benzene); iii. Esterification; iv. Complete combustion; v. Cracking/ reforming reactions; vi. Predict the relative reactivity of alkanes, alkenes, and alkynes).
- Write and balance chemical equations to predict the reactions of selected organic compounds. (319-8) (Draw structural diagrams of all organic reactants and products involved in: i. Incomplete combustion; ii. Elimination reactions). (Level 1 only)

Topic: Polymerization

- Describe processes of polymerization and identify some important natural and synthetic polymers. (319-9) (Define and outline the structures of monomers, polymers, and polymerization; Identify addition and condensation polymerization reactions).
- Define problems to facilitate investigation of polymers. (212-2)

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

- *Design an experiment* identifying and controlling major variables. (212-3)
- *Select and use apparatus and material safely*. (213-8)

Topic: Risks and Benefits of Organic Compounds: STSE Perspectives (1)

- Communicate questions ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others. (215-1)
- Describe and evaluate the design of technological solutions and the way they function using scientific principles. (116-6)
- Analyse from a variety of perspectives the risks and benefits to society and the environment of applying organic chemistry knowledge or introducing a particular technology. (118-2)
- Develop, present, and defend a position or course of action on organic chemistry based on findings. (215-5)

Topic: Risks and Benefits of Organic Compounds: STSE Perspectives (2)

- Select, integrate, and synthesize information from multiple sources including various print and electronic sources, and make inferences on this information. (213-7, 215-3)
- Debate the merits of funding specific scientific or technological endeavours and not others. (117-4)

Science, Technology, Society, and Environment (STSE) topics *should unfold organically in the virtual classroom; consider embedding these outcomes when teaching the Topic: Properties of Functional Groups.*

Exemplar tasks:
1. Ask students to compare the risks and benefits of various alcohols used as fuels: incorporating knowledge of functional groups as well as thermochemistry principles and create an artifact showing what they have discovered.
2. Provide students with an illustration of a commercial product that includes the active ingredients listed and the structure of the organic structure of the molecule. Ask student to (a) circle the functional group (s) on the molecule and (b) list which hydrocarbon derivative(s) are on the molecule.

Appendix A - Remaining Outcomes

These outcomes can be set aside for future learning.

Unit: Acids and Bases

Topic: Properties and Definitions of Acids and Bases (1)

- Describe and apply classification systems and nomenclature used in acids and bases. (214-1)
- Describe various acid-base definitions up to the Brønsted-Lowry definition. (320-1)

Topic: Properties and Definitions of Acids and Bases (2)

- Explain how acid-base theory evolved as new evidence and laws and theories were tested and revised or replaced (115-7) (Define a Brønsted-Lowry acid and a Brønsted-Lowry base).
- Explain the roles of evidence, theories, and paradigms in acid-base theories. (114-2) (Trace the development of acid-base theories from the original Arrhenius definition to the modern revised Arrhenius concept up to the Brønsted-Lowry theory).
- Introduce Lewis Acid and Bases Theory as the currently accepted theory (Level 1 only)

Topic: Acid/Base Reactions

- Predict products of acid-base reactions. (320-2)
- Identify new questions or problems that arise from what was learned. (214-17)
- Explain the importance of communicating the results of acid-base reactions using appropriate language and conventions. (114-9)

Topic: H+, OH- and Le Châtelier

- Describe the interactions between H+ ions and OH- ions using Le Châtelier's principle. (320-5) (Use Le Châtelier's principle to predict, qualitatively, shifts in acid-base equilibrium; Write the equation for, and explain, the self-ionization of water).
- Analyse society's influence on acid and base scientific and technological endeavours. (117-2)
- Construct arguments to support a decision using examples and evidence and recognizing various perspectives. (118-6)
- Identify and describe science-and technology-based careers related to acids and bases. (117-7)

Topic: Using the Equilibrium Concept with Acids and Bases (1)

- Compare strong and weak acids and bases using the concept of equilibrium. (320-3) (Understand that acid and base systems are quantitatively described, using pH, pOH, $[H_3O^+(aq)]$, $[OH^-(aq)]$, Kw, Ka, Kb, % dissociation, and concentration; Perform calculations to determine any of the above from empirical data; Define % dissociation, Ka and Kb qualitatively and relate their values to acid and base strength; Identify the values of pH and pOH associated with acidic and basic solutions).

Topic: Using the Equilibrium Concept with Acids and Bases (2)

- 3.6.1 Compare strong and weak acids and bases using the concept of equilibrium (continued). (320-3). (Understand that acid and base systems are quantitatively

described, using pH, pOH, [H_3O^+ (aq)], [OH^- (aq)], Kw, Ka, Kb, % dissociation, and concentration; Perform calculations to determine any of the above from empirical data; Perform calculations of equilibrium concentrations given initial concentration and K value for which the quadratic equation may be used; Perform calculations of equilibrium concentrations give [H+] or pH and the K value).

Topic: Using the Equilibrium Concept with Acids and Bases (3)

- Calculate the pH of an acid or base given its concentration, and vice versa. (320-4) (Calculate pH given the concentration of a strong acid or strong base; Calculate pH given the concentration of a weak acid or weak base along with the corresponding dissociation constant; Calculate pH from pOH, [H^+], [OH^-], and vice-versa).

Topic: Acid/Base Titrations (1)

- Determine the concentration of an acid or base solution using stoichiometry. (320-6)
- Select and use apparatus and material safely. (213-8)
- Use instruments effectively and accurately for collecting titration data. (213-3)
- Interpret patterns and trends in data and infer or calculate relationships among variables from titration labs. (214-5)
- Work co-operatively with team members to develop and carry out a plan for a titration lab and troubleshoot problems as they arise. (215-6)
- Evaluate and select appropriate instruments for collecting evidence and appropriate processes for titrations. (212-8)
- Select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, titrations, and results. (215-2)
- Demonstrate a knowledge of WHMIS standards by selecting proper techniques for handling and disposing of lab materials. (213-9)

Topic: Acid/Base Titrations (2)

- Explain how acid-base indicators function. (320-7) (Differentiate between the terms endpoint and equivalence point; Choose appropriate indicators for acid-base titrations).
- Analyse and describe examples where acid-base understanding was enhanced as a result of using titration curves. (116-2) (Qualitatively sketch and interpret titration curves).

Topic: Acid/Base Titrations (3)

- Identify a line/curve of best fit on a scatter plot and interpolate and extrapolate based on the line of best fit. (214-4) (Interpret, interpolate and extrapolate data from a titration curve; Graph sample data collected from a titration experiment or data provided by their teacher).
- State a prediction and hypothesis based on available evidence and background information. (212-4)
- Demonstrate the use of buffers in chemical systems especially in biological systems (e.g. blood). (Level 1 only)

Appendix B - Enablers

Pre-requisite knowledge, skills, and experiences required by learners which 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

- Basic arithmetic and rearranging equations.
- Units and their "behaviour" in calculations (ex. 2 m x 2 m = 4 m^2).
- Significant figures
- Scientific notation

Science concepts

- Difference between accuracy and precision
- Unit conversions and theory-based calculations using dimensional analysis.
- The use of quadratics to solve problems i.e. Ksp / Ka / Kb

Competencies

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

Subject specific

The following theory-related Chemistry 11 concepts support student learning for Chemistry 12:

a) Nomenclature
b) Five main types of chemical reactions and predicting products
c) Balancing chemical equations
d) Writing ionization equations
e) Concept of moles and calculations involving moles
f) Stoichiometry
g) Fundamentals of bonding (ionic bonding and ionic compounds vs. covalent bonding and covalent compounds)
h) Fundamentals of VSEPR theory (tetrahedral, trigonal pyramid, bent, trigonal planar, linear).
i) Electronegativity → bond polarity → molecular polarity (*requires VSEPR* and bond polarity*)

N.B. **VSEPR* was not discussed in detail in Chemistry-11 priority curriculum. The expectation was that students be able to *identify the shapes with the help of a reference aid*. Additional instruction will be required.

Appendix C - Online Learning Resources

American Association of Chemistry Teachers
Description: The *AACT* high school classroom resource library and multimedia collection has everything you need to put together a unit plan for your Chemistry lessons, activities, labs, projects, videos, simulations, and animations.

- Energy and Thermodynamics
- Equilibrium
- Kinetics
- Organic Chemistry

Bozeman Chemistry
Description: *Bozeman Chemistry* was created 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 Paul 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: *Chemistry*, 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 at the University of Colorado Boulder 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 Chemistry
Description: *TED-Ed's* mission is to capture and amplify the voices of great educators around the world. We do this by pairing extraordinary educators with talented animators to produce a new library of curiosity-igniting videos. Searchable by topic.
Website: https://ed.ted.com/search?qs=chemistry

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