SECTION 4:
DOCUMENT ORGANIZATION

Document Organization and Format *3*
Guide to Reading the Learning Outcomes and the Document Format *3*
Sample Two-Page Layout *6*
General Learning Outcomes *8*
Cluster 0: Skills and Attitudes Outcomes *10*
Specific Learning Outcomes *13*

DOCUMENT ORGANIZATION

Document Organization and Format

The suggestions for instruction and assessment contained within *Grade 12 Chemistry: A Foundation for Implementation* provide teachers with strategies for assisting students in achieving the general and specific learning outcomes identified for this curriculum. The instructional and assessment suggestions offer teachers a range of strategies from which to select appropriate directions with students. Although they are not prescriptive, the strategies presented can be considered starting points from which teachers can include their own initiatives, style, and effective techniques to foster learning.

The topic-related appendices (found at the end of each topic) and the general appendices (found at the end of this document) provide additional information on student learning activities, teacher support materials related to instruction and assessment, and a variety of assessment rubrics. These complementary resources are closely linked to the learning outcomes and to the skills and attitudes outcomes, and are designed to support, facilitate, and enhance student learning.

At-a-glance listings of the general learning outcomes, skills and attitudes outcomes, and specific learning outcomes for Grade 12 Chemistry are provided at the end of this section of this document, as well as in Appendix 12.

Guide to Reading the Learning Outcomes and the Document Format

The specific learning outcomes identified for Grade 12 Chemistry are organized according to the following five thematic topics:

- Topic 1: Reactions in Aqueous Solutions
- Topic 2: Atomic Structure
- Topic 3: Chemical Kinetics
- Topic 4: Chemical Equilibrium
- Topic 5: Acids and Bases
- Topic 6: Electrochemistry

The suggested strategies for implementing the curriculum outcomes within each chemistry topic include the following components:

- **Specific Learning Outcomes (SLOs):** The SLOs identified at the top of each page outline the intended learning to be achieved by the student by the end of the course. They include the SLOs related to the particular chemistry topic, in addition to the learning outcomes related to Cluster 0: Skills and Attitudes, selected to correspond to the Suggestions for Instruction.
- **General Learning Outcome (GLO) Connections:** The GLOs provide links across the entire scope of the Kindergarten to Grade 12 continuum of learning in science. These GLOs provide connections to the Five Foundations for Scientific Literacy that guide all Manitoba science curricula in all science discipline areas.

- **Suggestions for Instruction:** The instructional strategies relate directly to the achievement of the identified SLOs.
  - **Entry-Level Knowledge:** Students will have prior knowledge in relation to some learning outcomes. Identification of students' entry-level knowledge, where included, links instructors to key areas of the science curriculum from previous years, providing information about where students should be in relation to the present learning outcomes. Prior knowledge learning activities can then be used to provide students with a rationale about what is to come or to refresh conceptual or procedural knowledge that has lapsed over time.
  - **Student Learning Activities:** Student learning activities are suggested for all learning outcomes. The examples of teacher-facilitated instructional strategies presented in this document are designed to be student-centred, engaging the learner directly in some contextual way.
- **Teacher Notes:** Incorporated throughout this document as needed, these notes provide teachers with definitions and content background (often beyond what students are required to know), planning hints, special-interest material, cautions and safety information, and depth of treatment on certain issues related to the identified learning outcomes.
- **Suggestions for Assessment:** These suggestions offer strategies for assessing students' achievement of the specific learning outcomes.
- **Learning Resources Links:** The links to additional chemistry resources are intended to guide and support instruction, the learning process, and student assessment. While only titles, authors, and page references are provided in the Learning Resources Links for the specific learning outcome(s), the complete bibliographic information is cited in the Bibliography of this document. It is important to recognize that new editions of standard texts in the field of chemistry can be expected about every two years—often with minimal changes to content. The editions of learning resources identified in this document include those that were used directly in the preparation of *Grade 12 Chemistry: A Foundation for Implementation*. Teachers are encouraged to seek out newer versions of texts considered as "standards in the field."

  The following resources are cited most frequently in the **Learning Resources Links**:

  Chang, Raymond. *Chemistry*. 9th ed. Boston, MA: McGraw-Hill Higher Education, 2007.

  Chastko, Audrey, Jeff Goldie, Frank Mustoe, Ian Phillips, and Sandy Searle. *McGraw-Hill Ryerson Inquiry into Chemistry*. Toronto, ON: McGraw-Hill Ryerson, 2007.

  Davies, Lucille, Maurice Di Giuseppe, Ted Gibb, Milan Sanader, and Angela Vavitsas. *Nelson Chemistry 12: College Preparation*. Ontario Edition. Toronto, ON: Thomson Nelson, 2003.

  Davis, Joseph E., W. Keith McNab, Edward L. Haenisch, A. L. McClellan, and Paul R. O'Connor. *Laboratory Manual for Chemistry: Experiments and Principles.* Lexington, MA: D.C. Heath and Company, 1968.

  Dingrando, Laurel, Kathleen (Gregg) Tallman, Nichols Hainen, and Cheryl Wistrom. *Glencoe Chemistry: Matter and Change*. Columbus, OH: Glencoe/McGraw-Hill, 2005.

_____. *Glencoe Chemistry: Matter and Change: ChemLab and MiniLab Worksheets*. Columbus, OH: Glencoe/McGraw-Hill, 2002.

_____. *Glencoe Chemistry: Matter and Change, Laboratory Manual*. Columbus, OH: Glencoe/McGraw-Hill, 2005.

_____. *Glencoe Chemistry: Matter and Change: Small-Scale Laboratory Manual, Teacher Edition.* Columbus, OH: Glencoe/McGraw-Hill, 2002.

_____. *Glencoe Chemistry: Matter and Change, Teacher Wraparound Edition*. Columbus, OH: Glencoe/McGraw-Hill, 2005.

Fisher, Douglas. *Glencoe Chemistry: Matter and Change, Science Notebook*. Columbus, OH: Glencoe/McGraw-Hill, 2005.

Jenkins, Frank, Hans van Kessel, Lucille Davies, Oliver Lantz, Patricia Thomas, and Dick Tompkins. *Nelson Chemistry 11*. Ontario Edition. Toronto, ON: Nelson Thomson Learning, 2002.

Manitoba Education and Training. *Senior Years Science Teachers' Handbook: A Teaching Resource.* Winnipeg, MB: Manitoba Education and Training, 1997.

Merrill, Phyllis, Robert W. Parry, and Robert L. Tellefsen. *Chemistry: Experimental Foundations, Laboratory Manual.* 3rd ed. Englewood Cliffs, NJ: Prentice Hall, Inc., 1982.

Mustoe, Frank, Michael P. Jansen, Ted Doram, John Ivanco, Christina Clancy, and Anita Ghazariansteja. *McGraw-Hill Ryerson Chemistry*. Combined Atlantic Edition. Toronto, ON: McGraw-Hill Ryerson, 2004.

Penrose, Mike, Ted Gibb, Milan Sanader, and Angela Vavitsas. *Nelson Chemistry 12: College Preparation Teacher's Resource.* Toronto, ON: Nelson, 2004.

Phillips, John S., Victor S. Strozak, and Cheryl Wistrom. *Glencoe Chemistry: Concepts and Applications.* Columbus, OH: Glencoe/McGraw-Hill, 2005.

Silberberg, Martin S. *Chemistry: The Molecular Nature of Matter and Change*. 3rd ed. Boston, MA: McGraw-Hill Higher Education, 2003.

Slater, A., and G. Rayner-Canham. *Microscale Chemistry Laboratory Manual*. Reading, MA: Addison-Wesley Publishers Limited, 1994.

van Kessel, Hans, Frank Jenkins, Lucille Davies, Donald Plumb, Maurice Di Giuseppe, Oliver Lanz, and Dick Tompkins. *Nelson Chemistry 12*. Ontario Edition. Toronto, ON: Thomson Nelson, 2003.

Wagner, Maxine. *Prentice Hall Chemistry: The Study of Matter, Laboratory Manual.* 3rd ed. Needham, MA: Prentice Hall, Inc., 1989.

Waterman, Edward L., and Stephen Thompson. *Prentice Hall Chemistry: Small-Scale Chemistry Laboratory Manual.* Boston, MA: Pearson Prentice Hall, 2004.

Whitman, Ronald Laurie, and Ernest E. Zinck. *Prentice Hall Chemistry Today: Laboratory Manual*. Scarborough, ON: Prentice-Hall of Canada, 1976.

Wilbraham, Antony C., Dennis D. Staley, and Michael S. Matta. *Prentice Hall Chemistry: Laboratory Manual.* Boston, MA: Pearson Prentice Hall, n.d.

_____. *Prentice Hall Chemistry: Laboratory Manual, Teacher's Edition.* Boston, MA: Pearson Prentice Hall, n.d.

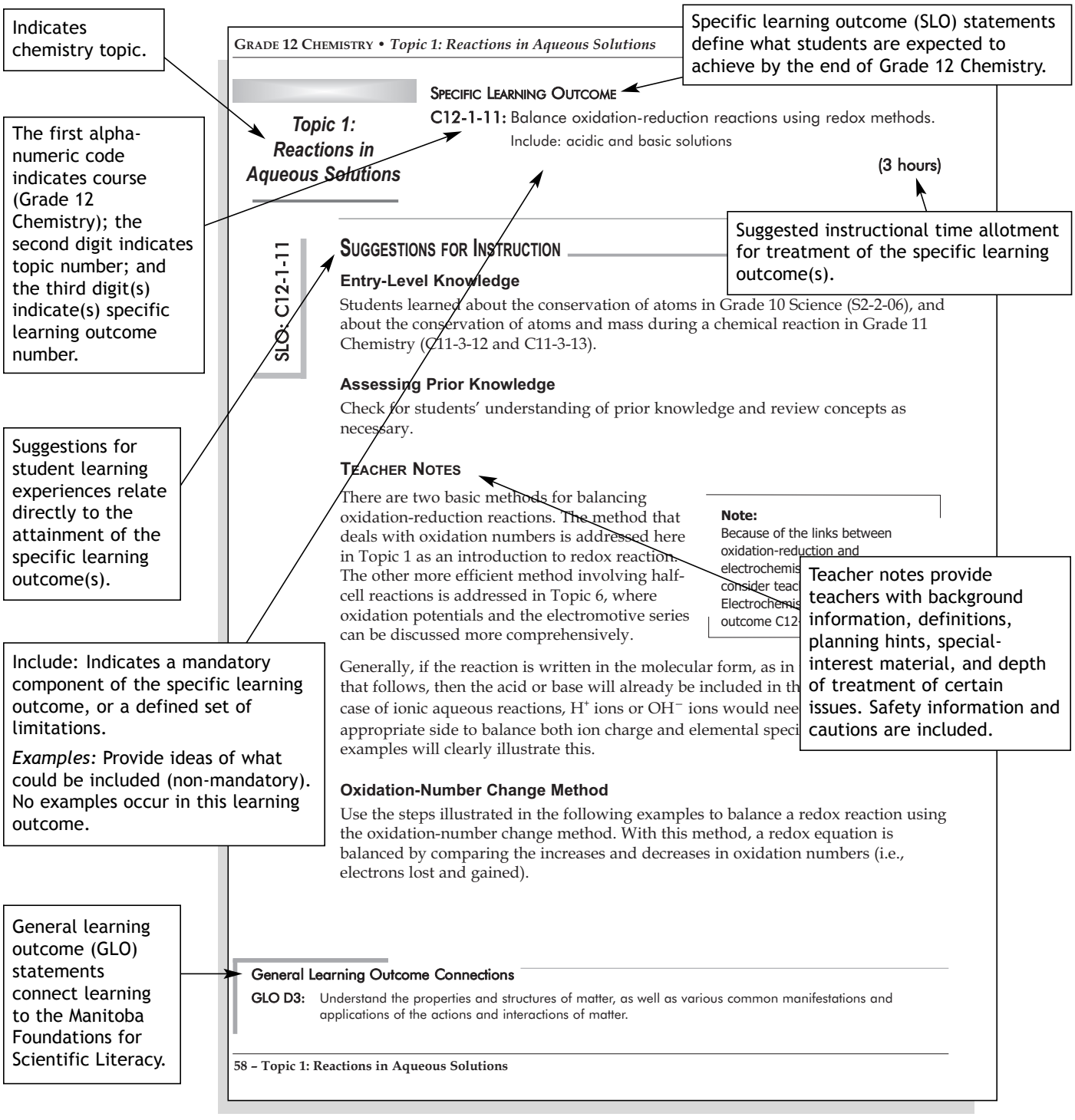
Wilbraham, Antony C., Dennis D. Staley, Michael S. Matta, and Edward L. Waterman. *Prentice Hall Chemistry.* Upper Saddle River, NJ: Pearson Education/Prentice Hall, 2005.

_____. *Prentice Hall Chemistry: Small-Scale Chemistry Laboratory Manual*. Upper Saddle River, NJ: Pearson Education/Prentice Hall, 2005.

Zumdahl, Steven S., and Susan A. Zumdahl. *Chemistry*. 5th ed. Boston, MA: Houghton-Mifflin, 2000.

Sample Two-Page Layout

The following clarification on reading the document format is based on a sample two-page layout from *Grade 12 Chemistry: A Foundation for Implementation*.



Skills and attitudes learning outcomes define expectations across all topics in Grade 12 Chemistry.

SKILLS AND ATTITUDES OUTCOMES

C12-0-U1: Use appropriate strategies and skills to develop an understanding of chemical concepts.

Examples: analogies, concept frames, concept maps, manipulatives, particulate representations, role-plays, simulations, sort-and-predict frames, word cycles . . .

C12-0-U2: Demonstrate an understanding of chemical concepts.

Examples: use accurate scientific vocabulary, explain concepts to others, compare and contrast concepts, apply knowledge to new situations and/or contexts, create analogies, use manipulatives . . .

SUGGESTIONS FOR ASSESSMENT

Paper-and-Pencil Task

Have students balance redox equations using process notes (see *SYSTH* 13.14).

Journal Writing

Students may wish to write an account of the technology that goes into the functioning and use of a traditional breathalyzer.

LEARNING RESOURCES LINKS

Glencoe Chemistry: Concepts and Applications (Phillips, Strozak, and Wistrom)
Breathalyzer Test, 569

Glencoe Chemistry: Matter and Change (Dingrando, et al.)
Section 20.2: Balancing Redox Equations, 644
The Oxidation-Number Method, 644
Section 20.3: Half-Reactions, 650

McGraw-Hill Ryerson Chemistry, Combined Atlantic Edition (Mustoe, et al.)
18.2: Oxidation Numbers, 721
18.3: The Half-Reaction Method for Balancing Equations, 730

Prentice Hall Chemistry (Wilbraham, et al.)
Section 20.3: Balancing Redox Equations, 645

Selecting Learning Resources

For additional information on selecting learning resources for Grade 11 and Grade 12 Chemistry, see the Manitoba Education website at <www.edu.gov.mb.ca/k12/learnres/bibliographies.html>.

Suggested assessment strategies relate directly to assessing student achievement of the specific learning outcome(s).

Links indicate the titles, authors, and page references (or URLs) where SLO-related content is treated within the various learning resources.

General Learning Outcomes

General learning outcomes (GLOs) provide connections to the Five Foundations for Scientific Literacy that guide all Manitoba science curricula in all science discipline areas.

Nature of Science and Technology

As a result of their Senior Years science education, students will:

A1 Recognize both the power and limitations of science as a way of answering questions about the world and explaining natural phenomena.

A2 Recognize that scientific knowledge is based on evidence, models, and explanations, and evolves as new evidence appears and new conceptualizations develop.

A3 Distinguish critically between science and technology in terms of their respective contexts, goals, methods, products, and values.

A4 Identify and appreciate contributions made by women and men from many societies and cultural backgrounds that have increased our understanding of the world and brought about technological innovations.

A5 Recognize that science and technology interact with and advance one another.

Science, Technology, Society, and the Environment (STSE)

As a result of their Senior Years science education, students will:

B1 Describe scientific and technological developments—past and present—and appreciate their impact on individuals, societies, and the environment, both locally and globally.

B2 Recognize that scientific and technological endeavours have been and continue to be influenced by human needs and the societal context of the time.

B3 Identify the factors that affect health, and explain the relationships among personal habits, lifestyle choices, and human health, both individual and social.

B4 Demonstrate knowledge of and personal consideration for a range of possible science- and technology-related interests, hobbies, and careers.

B5 Identify and demonstrate actions that promote a sustainable environment, society, and economy, both locally and globally.

Scientific and Technological Skills and Attitudes

As a result of their Senior Years science education, students will:

C1 Recognize safety symbols and practices related to scientific and technological activities and to their daily lives, and apply this knowledge in appropriate situations.

C2 Demonstrate appropriate scientific inquiry skills when seeking answers to questions.

C3 Demonstrate appropriate problem-solving skills when seeking solutions to technological challenges.

C4 Demonstrate appropriate critical thinking and decision-making skills when choosing a course of action based on scientific and technological information.

C5 Demonstrate curiosity, skepticism, creativity, open-mindedness, accuracy, precision, honesty, and persistence, and appreciate their importance as scientific and technological habits of mind.

C6 Employ effective communication skills and use information technology to gather and share scientific and technological ideas and data.

C7 Work cooperatively and value the ideas and contributions of others while carrying out scientific and technological activities.

C8 Evaluate, from a scientific perspective, information and ideas encountered during investigations and in daily life.

Essential Science Knowledge

As a result of their Senior Years science education, students will:

D1 Understand essential life structures and processes pertaining to a wide variety of organisms, including humans.

D2 Understand various biotic and abiotic components of ecosystems, as well as their interaction and interdependence within ecosystems and within the biosphere as a whole.

D3 Understand the properties and structures of matter, as well as various common manifestations and applications of the actions and interactions of matter.

D4 Understand how stability, motion, forces, and energy transfers and transformations play a role in a wide range of natural and constructed contexts.

D5 Understand the composition of the Earth's atmosphere, hydrosphere, and lithosphere, as well as the processes involved within and among them.

D6 Understand the composition of the universe, the interactions within it, and the implications of humankind's continued attempts to understand and explore it.

Unifying Concepts

As a result of their Senior Years science education, students will:

E1 Describe and appreciate the similarity and diversity of forms, functions, and patterns within the natural and constructed world.

E2 Describe and appreciate how the natural and constructed world is made up of systems and how interactions take place within and among these systems.

E3 Recognize that characteristics of materials and systems can remain constant or change over time, and describe the conditions and processes involved.

E4 Recognize that energy, whether transmitted or transformed, is the driving force of both movement and change, and is inherent within materials and in the interactions among them.

Cluster 0: Skills and Attitudes Outcomes

In Grade 12 Chemistry, Cluster 0 comprises four categories of specific learning outcomes that describe the skills and attitudes involved in scientific inquiry and the decision-making process for science, technology, society, and the environment (STSE) issues. From Grades 5 to 10, students develop scientific inquiry through the development of a hypothesis/prediction, the identification and treatment of variables, and the formation of conclusions. Students begin to make decisions based on scientific facts and refine their decision-making skills as they progress through the grades, gradually becoming more independent. Students also develop key attitudes, an initial awareness of the nature of science, and other skills related to research, communication, the use of information technology, and cooperative learning.

In Grade 12 Chemistry, students continue to use scientific inquiry as an important process in their science learning, but also recognize that STSE issues require a more sophisticated treatment through the decision-making process.

Teachers should select appropriate contexts to introduce and reinforce scientific inquiry, the decision-making process, and positive attitudes within the thematic topics (Topics 1 to 6) throughout the school year. To assist in planning and to facilitate curricular integration, many specific learning outcomes within the Skills and Attitudes cluster can link to specific learning outcomes in other subject areas.

Demonstrating Understanding

C12-0-U1 Use appropriate strategies and skills to develop an understanding of chemical concepts.

Examples: analogies, concept frames, concept maps, manipulatives, particulate representations, role-plays, simulations, sort-and-predict frames, word cycles . . .

C12-0-U2 Demonstrate an understanding of chemical concepts.

Examples: use accurate scientific vocabulary, explain concepts to others, compare and contrast concepts, apply knowledge to new situations and/or contexts, create analogies, use manipulatives . . .

Scientific Inquiry

C12-0-S1 Demonstrate work habits that ensure personal safety and the safety of others, as well as consideration for the environment.
Include: knowledge and use of relevant safety precautions, Workplace Hazardous Materials Information System (WHMIS), and emergency equipment

C12-0-S2 State a testable hypothesis or prediction based on background data or on observed events.

C12-0-S3 Design and implement an investigation to answer a specific scientific question.
Include: materials, independent and dependent variables, controls, methods, and safety considerations

C12-0-S4 Select and use scientific equipment appropriately and safely.
Examples: volumetric glassware, balance, thermometer . . .

C12-0-S5 Collect, record, organize, and display data using an appropriate format.
Examples: labelled diagrams, graphs, multimedia applications, software integration, probeware . . .

C12-0-S6 Estimate and measure accurately using Système International (SI) and other standard units.
Include: SI conversions and significant figures

C12-0-S7 Interpret patterns and trends in data, and infer and explain relationships.

C12-0-S8 Evaluate data and data-collection methods for accuracy and precision.
Include: discrepancies in data, sources of error, and percent error

C12-0-S9 Draw a conclusion based on the analysis and interpretation of data.
Include: cause-and-effect relationships, alternative explanations, and supporting or rejecting a hypothesis or prediction

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Research

C12-0-R1 Synthesize information obtained from a variety of sources.
Include: print and electronic sources, specialists, and other resource people

C12-0-R2 Evaluate information obtained to determine its usefulness for information needs.
Examples: scientific accuracy, reliability, currency, relevance, balance of perspectives, bias . . .

C12-0-R3 Quote from or refer to sources as required and reference information sources according to an accepted practice.

C12-0-R4 Compare diverse perspectives and interpretations in the media and other information sources.

C12-0-R5 Communicate information in a variety of forms appropriate to the audience, purpose, and context.

Communication and Teamwork

C12-0-C1 Collaborate with others to achieve group goals and responsibilities.

C12-0-C2 Elicit, clarify, and respond to questions, ideas, and diverse points of view in discussions.

C12-0-C3 Evaluate individual and group processes.

Nature of Science

C12-0-N1 Explain the roles of theory, evidence, and models in the development of scientific knowledge.

C12-0-N2 Describe, from a historical perspective, how the observations and experimental work of many individuals led to modern understandings of matter.

C12-0-N3 Describe how scientific knowledge changes as new evidence emerges and/or new ideas and interpretations are advanced.

STSE

C12-0-T1 Describe examples of the relationship between chemical principles and applications of chemistry.

C12-0-T2 Explain how scientific research and technology interact in the production and distribution of beneficial materials.

C12-0-T3 Provide examples of how chemical principles are applied in products and processes, in scientific studies, and in daily life.

Attitudes

C12-0-A1 Demonstrate confidence in their ability to carry out investigations in chemistry and to address STSE-related issues.

C12-0-A2 Value skepticism, honesty, accuracy, precision, perseverance, and open-mindedness as scientific and technological habits of mind.

C12-0-A3 Demonstrate a continuing, increasingly informed interest in chemistry and chemistry-related careers and issues.

C12-0-A4 Be sensitive and responsible in maintaining a balance between the needs of humans and a sustainable environment.

Specific Learning Outcomes

The specific learning outcomes (SLOs) identified here constitute the intended learning to be achieved by the student by the end of Grade 12 Chemistry. These statements clearly define what students are expected to achieve and/or be able to perform at the end of the course. These SLOs, combined with the Skills and Attitudes SLOs, constitute the source upon which assessment and instructional design are based.

Topic 1: Reactions in Aqueous Solutions

C12-1-01 Explain examples of solubility and precipitation at the particulate and symbolic levels.

C12-1-02 Perform a laboratory activity to develop a set of solubility rules.

C12-1-03 Use a table of solubility rules to predict the formation of a precipitate.

C12-1-04 Write balanced neutralization reactions involving strong acids and bases.

C12-1-05 Perform a laboratory activity to demonstrate the stoichiometry of a neutralization reaction between a strong base and a strong acid.

C12-1-06 Calculate the concentration or volume of an acid or a base from the concentration and volume of an acid or a base required for neutralization.

C12-1-07 Design and test a procedure to determine the identity of a variety of unknown solutions.

C12-1-08 Outline the development of scientific understanding of oxidation and reduction reactions.

Include: gain and loss of electrons, oxidizing agent, and reducing agent

C12-1-09 Determine the oxidation numbers for atoms in compounds and ions.

C12-1-10 Identify reactions as redox or non-redox.

Include: oxidizing agent, reducing agent, oxidized substance, and reduced substance

C12-1-11 Balance oxidation-reduction reactions using redox methods.

Include: acidic and basic solutions

C12-1-12 Research practical applications of redox reactions.

Examples: rocket fuels, fireworks, household bleach, photography, metal recovery from ores, steel making, aluminum recycling, fuel cells, batteries, tarnish removal, fruit clocks, forensic blood detection using luminol, chemiluminescence/ bioluminescence, electrolytic cleaning, electrodeposition, photochemical etching, antioxidants/ preservatives . . .

Topic 2: Atomic Structure

C12-2-01 Describe qualitatively the electromagnetic spectrum in terms of frequency, wavelength, and energy.

C12-2-02 Recognize, through direct observation, that elements have unique line spectra.

Include: flame tests or gas discharge tubes and spectroscopes or diffraction gratings

C12-2-03 Describe applications and/or natural occurrences of line spectra.

Examples: astronomy, aurora borealis, fireworks, neon lights . . .

C12-2-04 Outline the historical development of the quantum mechanical model of the atom.

C12-2-05 Write electron configurations for elements of the periodic table.

Include: selected elements up to atomic number 36 (krypton)

C12-2-06 Relate the electron configuration of an element to its valence electron(s) and its position on the periodic table.

C12-2-07 Identify and account for periodic trends among the properties of elements, and relate the properties to electron configuration.

Include: atomic radii, ionic radii, ionization energy, and electronegativity

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Topic 3: Chemical Kinetics

C12-3-01 Formulate an operational definition of *reaction rate*.

Include: examples of chemical reactions that occur at different rates

C12-3-02 Identify variables used to monitor reaction rates (i.e., change per unit of time, $\Delta x/\Delta t$).

Examples: pressure, temperature, pH, conductivity, colour . . .

C12-3-03 Perform a laboratory activity to measure the average and instantaneous rates of a chemical reaction.

Include: initial reaction rate

C12-3-04 Relate the rate of formation of a product to the rate of disappearance of a reactant, given experimental rate data and reaction stoichiometry.

Include: descriptive treatment at the particulate level

C12-3-05 Perform a laboratory activity to identify factors that affect the rate of a chemical reaction.

Include: nature of reactants, surface area, concentration, pressure, volume, temperature, and presence of a catalyst

C12-3-06 Use the collision theory to explain the factors that affect the rate of chemical reactions.

Include: activation energy and orientation of molecules

C12-3-07 Draw potential energy diagrams for endothermic and exothermic reactions.

Include: relative rates, effect of a catalyst, and heat of reaction (enthalpy change)

C12-3-08 Describe qualitatively the relationship between the factors that affect the rate of chemical reactions and the relative rate of a reaction, using the collision theory.

C12-3-09 Explain the concept of a reaction mechanism.

Include: rate-determining step

C12-3-10 Determine the rate law and order of a chemical reaction from experimental data.

Include: zero-, first-, and second-order reactions and reaction rate versus concentration graphs

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Topic 4: Chemical Equilibrium

C12-4-01 Relate the concept of equilibrium to physical and chemical systems.

Include: conditions necessary to achieve equilibrium

C12-4-02 Write equilibrium law expressions from balanced chemical equations for heterogeneous and homogeneous systems.

Include: mass action expression

C12-4-03 Use the value of the equilibrium constant (K_{eq}) to explain how far a system at equilibrium has gone towards completion.

C12-4-04 Solve problems involving equilibrium constants.

C12-4-05 Perform a laboratory activity to determine the equilibrium constant of an equilibrium system.

C12-4-06 Use Le Châtelier's principle to predict and explain shifts in equilibrium.

Include: temperature changes, pressure/volume changes, changes in reactant/product concentration, the addition of a catalyst, the addition of an inert gas, and the effects of various stresses on the equilibrium constant

C12-4-07 Perform a laboratory activity to demonstrate Le Châtelier's principle.

C12-4-08 Interpret concentration versus time graphs.

Include: temperature changes, concentration changes, and the addition of a catalyst

C12-4-09 Describe practical applications of Le Châtelier's principle.

Examples: Haber process, hemoglobin production at high altitude, carbonated beverages, eyes adjusting to light, blood pH, recharging of batteries, turbocharged/supercharged engines, ester synthesis, weather indicators, arrangement of produce, carbonated beverages in a hen's diet . . .

C12-4-10 Write solubility product (K_{sp}) expressions from balanced chemical equations for salts with low solubility.

C12-4-11 Solve problems involving K_{sp}.
Include: common ion problems

C12-4-12 Describe examples of the practical application of salts with low solubility.
Examples: kidney stones, limestone caverns, osteoporosis, tooth decay . . .

C12-4-13 Perform a laboratory activity to determine the K_{sp} of a salt with low solubility.

Topic 5: Acids and Bases

C12-5-01 Outline the historical development of acid-base theories.
Include: the Arrhenius, Brønsted-Lowry, and Lewis theories

C12-5-02 Write balanced acid-base chemical equations.
Include: conjugate acid-base pairs and amphoteric behaviour

C12-5-03 Describe the relationship between the hydronium and hydroxide ion concentrations in water.
Include: the ion product of water, K_w

C12-5-04 Perform a laboratory activity to formulate an operational definition of *pH*.

C12-5-05 Describe how an acid-base indicator works in terms of colour shifts and Le Châtelier's principle.

C12-5-06 Solve problems involving pH.

C12-5-07 Distinguish between strong and weak acids and bases.
Include: electrolytes and non-electrolytes

C12-5-08 Write the equilibrium expression (K_a or K_b) from a balanced chemical equation.

C12-5-09 Use K_a or K_b to solve problems for pH, percent dissociation, and concentration.

C12-5-10 Perform a laboratory activity to determine the concentration of an unknown acid or base, using a standardized acid or base.

C12-5-11 Predict whether an aqueous solution of a given ionic compound will be acidic, basic, or neutral, given the formula.

Topic 6: Electrochemistry

C12-6-01 Develop an activity series experimentally.

C12-6-02 Predict the spontaneity of reactions using an activity series.

C12-6-03 Outline the historical development of voltaic (galvanic) cells.
Include: contributions of Luigi Galvani and Alessandro Volta

C12-6-04 Explain the operation of a voltaic (galvanic) cell at the visual, particulate, and symbolic levels.
Include: writing half-cell reactions, the overall reaction, and shorthand (line) notation

C12-6-05 Construct a functioning voltaic (galvanic) cell and measure its potential.

C12-6-06 Define *standard electrode potential*.
Include: hydrogen electrode as a reference

C12-6-07 Calculate standard cell potentials, given standard electrode potentials.

C12-6-08 Predict the spontaneity of reactions using standard electrode potentials.

C12-6-09 Compare and contrast voltaic (galvanic) and electrolytic cells.

C12-6-10 Explain the operation of an electrolytic cell at the visual, particulate, and symbolic levels.
Include: a molten ionic compound and an aqueous ionic compound

C12-6-11 Describe practical uses of electrolytic cells.
Examples: electrolysis of water, electrolysis of brine, electroplating, production and purification of metals . . .

C12-6-12 Using Faraday's law, solve problems related to electrolytic cells.

NOTES