Manitoba Rural Learning Consortium
Grades 11 & 12 Chemistry
Essential Learning Document

Acknowledgements

This document has been developed by Senior Years teachers from across rural Manitoba. The Manitoba Rural Learning Consortium (mRLC) Grade 11 and 12 Chemistry Essential Learning Cohort was made up of the following members:

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Introduction

What is scientific literacy?

Science students utilize a scientific perspective when thinking critically, making informed decisions, and applying their understandings to the world around them. Students demonstrate the following:

- an interest in science and technology
- a growing understanding of the big ideas of science in context and the rules that govern them.
- a skills set unique to science that will benefit future interests or studies.
- an ability to effectively communicate their ideas and appreciate other viewpoints
- an ability to apply their scientific knowledge concerning STSE and living sustainably.
- an ability to be innovative thinkers, capable of problem-solving, making informed decision, and creating new knowledge.
- the confidence to ask, to test, to create, to take risks, and to interpret.

Science should be accessible to all. Therefore, we recognize that there are different levels of scientific literacy based on the above characteristics.

What is essential learning?

One encounters many similar terms when reading about curriculum reform: essential outcomes, essential learning, concept-based curriculum, and more. Each of these initiatives attempt to help teachers and students make better sense of the content that is being taught in their classrooms by restructuring, reordering and regrouping specific curricular outcomes.

It is important to note that essential learning should not be interpreted as an attempt to remove outcomes from the curriculum. Rather, one could think of this as an effort to see the forest first and then look at all the trees. Furthermore, while looking at the trees it should be remembered that they make up a forest.

When teaching is focused on creating a deep understanding of the underlying principles and pillars of a discipline we unveil the 'essence' of that subject and, hopefully, our students develop a better understanding of what it means to study "chemistry". By communicating and organizing curriculum around the 'big ideas' of our subject, we aim to help students make better connections with the specific learning outcomes we are teaching and, hopefully, all the knowledge, skills and attitudes we have taught them are much more meaningful and endure into the future.

The Essential Learning section of this document is a restructuring of the specific learning outcomes (SLOs) in the Grade 11 and Grade 12 Chemistry curricula around the applicable Big Ideas or Enduring Understandings in chemistry. Essential Questions have been developed which are meant to be open, thought-provoking questions and, if a student can answer fully, will indicate an understanding of the associated big ideas. To help in assessment and reporting, the curricular outcomes have been divided into the three categories as deemed appropriate: Knowledge and Understanding, Scientific Inquiry, Process and Design and STSE's. **Enduring Understandings** and **Essential Questions** have been written for each category with a horizontal connection between the three categories within each unit**.**

Goals for Canadian Science Education

Several goals promoting the achievement of scientific literacy within Canadian science education were developed as part of the Pan-Canadian Science Framework.

These goals are addressed through the Manitoba science curricula. It is hoped that science education will:

- encourage students at all levels to develop a rational sense of wonder and curiosity about scientific and technological endeavours
- enable students to use science and technology to acquire new knowledge and to solve problems, so they may improve the quality of their own lives and the lives of others
- prepare students to address science-related societal, economic, ethical, and environmental issues critically
- provide students with a proficiency in science that creates opportunities for them to pursue progressively higher levels of advanced study, prepares them for science-related occupations, and engages them in science-related activities appropriate to their interests and abilities
- develop in students of varying aptitudes and interests a knowledge of the wide variety of careers related to science, technology, and support for the natural and human environments

Taken from: *Grade 11 Chemistry. A Foundation for Implementation*

Cluster 0: Skills and Attitudes Outcomes

The specific learning outcomes of Cluster 0 are imbedded within the Chemistry 11/12 curriculum topic charts.

Grade 11 Chemistry

Essential Vocabulary:

Kinetic molecular theory, Pressure, Boyle, Charles, Gay-Lussac, isotopes, polyatomic compound names and formulas, balanced chemical equations, mole, molar mass, empirical and molecular formulas, stoichiometric problems, limiting and excess reactants, solution types, polar and non-polar substances, saturated, unsaturated, and supersaturated, concentration, hydrocarbons, alkanes, alkenes, alkynes, branched alkanes, isomers, aromatic hydrocarbons, aliphatic hydrocarbons, alcohols, organic acids, esters

Critical Thinking skills:

Illustrate, Explain, Observe, Describe, Investigate, Compare and Contrast, Outline, Collect, Analyze, Differentiate, Discuss, Decide, Interpret, Document, Classify

Inquiry Skills:

1. Initiate
   - Ask testable questions
   - Justify methods
2. Research
   - Select, integrate, evaluate and summarize information
3. Plan
   - Make a hypothesis and rationale
   - Identify variable relationships
   - Make a plan
4. Implement a Plan
   - Conduct a fair test
   - Use safe work habits
   - Work cooperatively
5. Observe, Measure, and Record
   - Use proper tools and methods
   - Estimate and measure with SI units
   - Record observations effectively
6. Analyze and Interpret
   - Interpret trends
   - Explain discrepancies and suggest improvements
7. Conclude and Apply
   - Draw conclusions
   - Reflect on original hypothesis
   - Summarize learning
8. Reflect on Science and Technology
9. Demonstrate positive attitudes

Topic 1: Physical Properties of Matter

Essential Vocabulary: kinetic molecular theory, density, compressibility, diffusion, random motion, intermolecular forces, elastic collisions, average kinetic energy, temperature, freezing point, boiling point, normal boiling point, exothermic, endothermic, intermolecular forces, random motion, volatility, dynamic, equilibrium, & vapour pressure

Knowledge and Understanding		**Scientific Inquiry**	**Scientific Inquiry S, C1, A1, A2**	**Process and Design & STSE**	**Process and Design & STSE: R, C2, C3, D, A1, A2, A3, A4**
Enduring Understanding	**Essential Questions**	**Enduring Understanding**	**Essential Questions**	**Enduring Understanding**	**Essential Questions**
The Kinetic Molecular Theory (KMT) explains physical properties of matter.	How are the physical properties of matter related to the KMT? C11-1-01 C11-0-U1	Scientific inquiry requires the use of specific skills developed along a continuum and demonstrates a sensitivity towards the environment.	How would you use scientific inquiry in everyday life? C11-0-S2 C11-0-S9 C11-0-S3 C11-0-A1	Scientific research should consider the science, technology, society, and environment in any situation.	How do you conduct appropriate and valid research? C11-0-R1 C11-0-R5 C11-0-R2 C11-0-C2 C11-0-R3 C11-0-R4
	What does the KMT reveal about the properties of gases? C11-1-02 C11-0-U1		How do you demonstrate appropriate work habits and consideration for the environment? C11-0-S1 C11-0-C2 C11-0-S4 C11-0-C3 C11-0-C1	Effective decision-making requires careful consideration of a number of factors.	How do you use scientific research to make an informed decision? C11-0-D1 C11-0-D5 C11-0-D2 C11-0-D6 C11-0-D3 C11-0-A4 C11-0-D4
	How does the KMT explain the processes of evaporation and condensation? C11-1-05	The scientific inquiry process is cyclic with certain steps that can be revisited and is open to improvement.	How do you know that you conducted a fair test? C11-0-S6 C11-0-S8 C11-0-A2	Scientific literacy is necessary to understand local and global issues.	How does scientific literacy affect your everyday life? C11-0-A1 C11-0-A3 C11-0-A2 C11-0-A4
All substances have an identifiable boiling point and vapour pressure.	How do you operationally define the normal boiling point and vapour pressure of a substance? C11-1-06 C11-1-08 C11-1-07 C11-0-U2	Lab safety is essential.	Why is lab safety important? How do you know that you are working safely? C11-0-S1		

Topic 2: Gases and the Atmosphere

Essential Vocabulary: pressure, Boyle, Charles, Gay-Lussac, atmospheres (atm), kilopascals (kPa), millimetres of mercury (mmHg), millibars (mb), the relationship between pressure, volume, temperature, the determination of absolute zero, the Kelvin temperature scale, symbolic relationship

Knowledge and Understanding		**Scientific Inquiry**	**Scientific Inquiry S, C1, A1, A2**	**Process and Design & STSE**	**Process and Design & STSE: R, C2, C3, D, A1, A2, A3, A4**
Enduring Understanding	**Essential Questions**	**Enduring Understanding**	**Essential Questions**	**Enduring Understanding**	**Essential Questions**
Relationships exist between pressure, temperature, volume and numbers of moles of gases.	How can gas laws be used to explain the behavior of gases? C11-2-05 C11-2-08 C11-2-06 C11-0-U1 C11-2-07 C11-0-U2	Scientific Inquiry requires data collection, interpretation, evaluation, and communication of conclusions.	How do we communicate collected data? C11-0-S5 C11-0-S7 C11-0-S8 C11-0-S9	Scientific research should consider the science, technology, society, and environment in any situation.	How do you conduct appropriate and valid research? C11-0-R1 C11-0-R5
	How has pressure been measured historically? C11-2-03 C11-0-U1 C11-2-04 C11-0-U2				
Atmospheric composition is continually changing.	How has the abundance of atmospheric gases changed over time? C11-2-01	The scientific inquiry process is cyclic with certain steps that can be revisited and is open to improvement	How do you estimate, collect, record, organize, and display data appropriately? C11-0-S5	Scientific research should consider the science, technology, society, and environment in any situation.	How do you conduct appropriate and valid research? C11-0-R1 C11-0-R2 C11-0-R4 C11-0-R5
	How are we/might we improve air quality? C11-2-02				How do you conduct appropriate and valid research? C11-0-R1 C11-0-R2 C11-0-R4 C11-0-R5
	How do we use gases in our daily lives? C11-2-09	Lab safety is essential.	Why is lab safety important? How do you know that you are working safely? C11-0-C1		How do you conduct appropriate and valid research within a group setting? C11-0-C1 C11-0-R1 C11-0-R3 C11-0-R5

Topic 3: Chemical Reactions

Essential Vocabulary: atomic mass units, isotopes, relative abundance, polyatomic ions, mole, molar mass, molar volume, standard temperature and pressure (STP), empirical formula, molecular formula, percent composition, stoichiometry, limiting reactant, theoretical yield, experimental yield, mole ratio

Knowledge and Understanding		**Scientific Inquiry**	**Scientific Inquiry S, C1, A1, A2**	**Process and Design & STSE**	**Process and Design & STSE: R, C2, C3, D, A1, A2, A3, A4**
Enduring Understanding	**Essential Questions**	**Enduring Understanding**	**Essential Questions**	**Enduring Understanding**	**Essential Questions**
All chemical substances have unique quantifiable physical properties.	How do isotopes relate to the mole? C11-3-01 C11-0-U1 C11-3-02 C11-0-U2	Scientific Inquiry requires data collection, interpretation, evaluation, and communication of conclusions.	How do we communicate collected data? C11-0-S7	Scientific research should consider the science, technology, society, and environment in any situation.	How do you conduct appropriate and valid research? C11-0-R1 C11-0-R2 C11-0-R5
	How is the concept of the mole used as a measurement tool in chemistry? C11-3-04 C11-0-U1 C11-3-07 C11-0-U2 C11-3-08		How do we communicate collected data? C11-0-S7		
Chemical reactions can be represented in a systematic way.	How do you construct a chemical reaction? C11-3-03 C11-0-U1 C11-3-05 C11-0-U2 C11-3-06		How do we communicate collected data? C11-0-S7 C11-0-S9		
Chemical substances can be quantified.	How are density and molar volume related? C11-3-09 C11-0-U2 C11-0-U1		How do we communicate collected data? C11-0-S7		

(Page 2) Knowledge and understanding		Scientific Inquiry	Scientific Inquiry S, C1, A1, A2	Process and Design & STSE	Process and Design & STSE: R, C2, C3, D, A1, A2, A3, A4
Enduring Understanding	**Essential Questions**	**Enduring Understanding**	**Essential Questions**	**Enduring Understanding**	**Essential Questions**
	What are the quantitative relationships between mass, volume, moles and number of particles for a chemical substance? C11-3-10 C11-0-U2 C11-0-U1		How do we communicate collected data? C11-0-S7		
	How are percent composition and/or mass data related to chemical formulas? C11-3-11 C11-0-U2 C11-0-U1		How do we communicate collected data? C11-0-S7		
Chemical reactions are quantifiable and applicable to industrial processes.	How can you determine the stoichiometric relationships within a chemical reaction? C11-3-12 C11-3-15 C11-3-13 C11-0-U1 C11-3-14 C11-0-U2	Scientific Inquiry requires data collection, interpretation, evaluation, and communication of conclusions. Lab safety is essential.	How do we communicate collected data? How do you demonstrate lab safety? C11-0-S1 C11-0-S7 C11-0-S3 C11-0-S9 C11-0-S5		
	How is stoichiometry used in industry? C11-3-16				How do you conduct appropriate and valid research? C11-0-R1 C11-0-R2 C11-0-R3 C11-0-R5

Topic 4: Solutions

Essential Vocabulary: crystal structure, dissociation, hydration, soluble, insoluble, miscible, immiscible, grams per litre (g/L), % weight-weight (% w/w), % weight-volume (% w/v), % volume/volume (% v/v), parts per million (ppm), parts per billion (ppb), moles per litre (mol/L) (molarity), dilution of stock solutions, unsaturated, saturated, supersaturated, concentration, solution types, polar and non-polar substances

Knowledge and Understanding		**Scientific Inquiry**	**Scientific Inquiry S, C1, A1, A2**	**Process and Design & STSE**	**Process and Design & STSE: R, C2, C3, D, A1, A2, A3, A4**
Enduring Understanding	**Essential Questions**	**Enduring Understanding**	**Essential Questions**	**Enduring Understanding**	**Essential Questions**
Solutions have identifiable characteristics (solute/solvent, saturated/unsaturated)	What are the characteristics of the nine types of solutions? C11-4-01 C11-0-U1			Scientific research should consider the science, technology, society, and environment in any situation.	How do you conduct appropriate and valid research? C11-0-R1
	How does the structure of water make it an effective solvent? C11-4-02 C11-0-U1				How do you conduct appropriate and valid research? C11-0-R1
	How are solutions formed? C11-4-03 C11-0-U1 C11-4-07	Scientific Inquiry requires data collection, interpretation, evaluation, and communication of conclusions. Lab safety is essential.	How do we communicate collected data? C11-0-S7 C11-0-S9		How do you conduct appropriate and valid research? C11-0-R1
	How does the nature of substances affect solubility? C11-4-05		How do we communicate collected data? How do you demonstrate lab safety? C11-0-S1 C11-0-S4 C11-0-S5		
	How do solutes affect colligative properties? C11-4-11 C11-0-U1 C11-4-12 C11-0-U2		How do we communicate collected data? How do you demonstrate lab safety? C11-0-S5 C11-0-S7 C11-0-S9		

(Page 2) Knowledge and Understanding		Scientific Inquiry	Scientific Inquiry S, C1, A1, A2	Process and Design & STSE	Process and Design & STSE: R, C2, C3, D, A1, A2, A3, A4
Enduring Understanding	**Essential Questions**	**Enduring Understanding**	**Essential Questions**	**Enduring Understanding**	**Essential Questions**
Environmental factors affect solubility.	How do changes in temperature and pressure affect the solubility of gases? C11-4-09 C11-0-U1 C11-4-10 C11-0-U2			Scientific literacy is necessary to understand local and global issues.	Identify, evaluate, and justify a position on a current STSE issue. C11-0-D1 C11-0-D2
	How do chemists interpret solubility data? C11-4-08 C11-0-U2 C11-4-06	Scientific inquiry requires the use of specific skills developed along a continuum and demonstrates a sensitivity towards the environment.	How would you use scientific inquiry in everyday life? How do we communicate collected data? C11-0-S2 C11-0-S7 C11-0-S8 C11-0-S9		
Solutions have quantifiable characteristics.	How can solution concentration be represented? C11-4-13 C11-0-U1 C11-4-14 C11-0-U2	Scientific Inquiry requires data collection, interpretation, evaluation, and communication of conclusions.			
	How can the concentration of a solution be determined experimentally? C11-4-15	Scientific Inquiry requires the appropriate scientific equipment and measurement accuracy	How do you identify the correct apparatus and use it to measure accurately? C11-0-S4 C11-0-S6		
	How can stock solutions be diluted in the lab? C11-4-16 C11-0-U1 C11-4-17 C11-0-U2				
Knowing the concentration of solutions is important in many aspects of life.	How is solution concentration applied in the larger world? C11-4-04 C11-0-U1 C11-4-18 C11-0-U2 C11-4-19	Scientific Inquiry requires that collected data be analyzed and conclusions drawn to support or reject a hypothesis.	How can we draw effective conclusions based upon data collected? C11-0-S9 C11-0-A1	Scientific research should consider the science, technology, society, and environment in any situation Scientific literacy is necessary to understand local and global issues.	How do you conduct appropriate valid research and justify a position on a current STSE issue? C11-0-R1 C11-0-R2 C11-0-R3 C11-0-R5 C11-0-D1 C11-0-D2 C11-0-D3

Topic 5: Organic Chemistry

Essential Vocabulary: natural and synthetic sources, organic and inorganic compounds, hydrocarbons, saturated and unsaturated hydrocarbons, alkanes, alkenes, alkynes, IUPAC nomenclature, structural formulas, condensed, structural formulas, molecular formulas, general formula, dehydrogenation/hydrogenation, molecular models, branched alkanes, isomers, aromatic hydrocarbons, aliphatic hydrocarbons, alcohols, organic acids, esters

Knowledge and Understanding		**Scientific Inquiry**	**Scientific Inquiry S, C1, A1, A2**	**Process and Design & STSE**	**Process and Design & STSE: R, C2, C3, D, A1, A2, A3, A4**
Enduring Understanding	**Essential Questions**	**Enduring Understanding**	**Essential Questions**	**Enduring Understanding**	**Essential Questions**
Organic compounds are the basis of life.	How has the understanding of organic substances contributed to the physical sciences? C11-5-01 C11-0-U1 C11-5-02	Scientific Inquiry requires data collection, interpretation, evaluation, and communication of conclusions. Lab safety is essential.	How do we communicate collected data? Why is lab safety important? How do you know that you are working safely? C11-0-C1 C11-0-S1	Scientific research should consider the science, technology, society, and environment in any situation	How do you conduct appropriate and valid research? C11-0-R1
Bonding characteristics of carbon explain physical and chemical properties of organic compounds	What are the bonding characteristics of the carbon atom? C11-5-03 C11-0-U1				How do you conduct appropriate and valid research? C11-0-R1
	How does structure influence aliphatic characteristics? C11-5-04 C11-5-09 C11-5-05 C11-5-10 C11-5-06 C11-5-11 C11-5-07 C11-5-12 C11-5-08 C11-0-U1				How do you conduct appropriate valid research and justify a position on a current STSE issue? C11-0-R1 C11-0-D4 C11-0-D5

(Page 2) Knowledge and Understanding		Scientific Inquiry	Scientific Inquiry S, C1, A1, A2	Process and Design & STSE	Process and Design & STSE: R, C2, C3, D, A1, A2, A3, A4
Enduring Understanding	**Essential Questions**	**Enduring Understanding**	**Essential Questions**	**Enduring Understanding**	**Essential Questions**
	Why are aromatic hydrocarbons unique? C11-5-13 C11-0-U1 C11-5-14			Scientific research should consider the science, technology, society, and environment in any situation.	How do you conduct appropriate and valid research? C11-0-R1
	How are substituted hydrocarbons classified? C11-5-15 C11-5-19 C11-5-16 C11-5-20 C11-5-17 C11-5-21 C11-5-18 C11-0-U1	.			How do you conduct appropriate and valid research? C11-0-R1
Organic chemistry is important to economic growth.	Describe how the development of organic compounds has influenced industrial processes. C11-5-22 C11-5-24 C11-5-23 C11-0-U1		How do we communicate collected data within a group? How do you demonstrate lab safety within a group? C11-0-S1 C11-0-S9 C11-0-C1	Scientific research should consider the science, technology, society, and environment in any situation.	Identify, evaluate, and justify a position on a current STSE issue. C11-0-C3 C11-0-D4 C11-0-D1 C11-0-D5 C11-0-D2 C11-0-D6 C11-0-D3 C11-0-R1

Grade 12 Chemistry

Essential Vocabulary:

solubility, precipitation, soluble, insoluble, precipitate, neutralization reaction, strong acid, weak acid, strong base, weak base, salt, oxidation reaction, reduction reaction, oxidizing agent, reducing agent, oxidation numbers, ion, redox, electromagnetic spectrum, frequency, wavelength, energy, line spectra, Quantum Mechanical Model, electron configurations, atomic radii, ionic radii, ionization energy, electronegativity, periodic trend, reaction rate, initial rate, average rate, instantaneous rate, nature of reactants, surface area, equilibrium, equilibrium law expression, equilibrium constant, heterogeneous, homogeneous, ICE Table Method, BIR/PEC Accounting Method, Le Chatelier's Principle, shift in equilibrium, solubility product expression (Ksp), common ion expression (Qsp), Arrhenius, Bronsted-Lowry, Lewis, conjugate acid/base pairs, amphoteric behaviour, hydronium ion, ion product constant (K_w), pH, pOH, acid/base indicator, electrolyte, non-electrolyte, K_a, K_b, standardized acid, standardized base, acid solution, basic solution, neutral solution, salt, neutralization, titration, end point, titration curve, activity series, standard oxidation potentials, standard reduction potentials, spontaneity of reactions, voltaic (galvanic) cells, half-cell reactions, standard electrical potential (voltage), standard potential, electrolytic cells, electrodes, electrolysis, electroplating, salt bridge, Faraday's Law, polarization

Critical Thinking Skills:

Illustrate, Explain, Observe, Describe, Investigate, Compare and Contrast, Outline, Collect, Analyze, Differentiate, Discuss, Decide, Interpret, Document, Classify

Inquiry Skills:

1. Initiate
   - Ask testable questions
   - Justify methods
2. Research
   - Select, integrate, evaluate and summarize information
3. Plan
   - Make a hypothesis and rationale
   - Identify variable relationships
   - Make a plan
4. Implement a Plan
   - Conduct a fair test
   - Use safe work habits
   - Work cooperatively
5. Observe, Measure, and Record
   - Use proper tools and methods
   - Estimate and measure with SI units
   - Record observations effectively
6. Analyze and Interpret
   - Interpret trends
   - Explain discrepancies and suggest improvements
7. Conclude and Apply
   - Draw conclusions
   - Reflect on original hypothesis
   - Summarize learning
8. Reflect on Science and Technology
9. Demonstrate positive Attitudes

Topic 1: Aqueous solutions

Essential Vocabulary: solubility, precipitation, soluble, insoluble, precipitate, neutralization reaction, strong acid, weak acid, strong base, weak base, salt, oxidation reaction, reduction reaction, oxidizing agent, reducing agent, oxidation numbers, ion, redox

Knowledge and Understanding		Scientific Inquiry	Scientific Inquiry S, C1, A1, A2	Process and Design & STSE	Process and Design & STSE: R, C2, C3, D, A1, A2, A3, A4
Enduring Understanding	**Essential Questions**	**Enduring Understanding**	**Essential Questions**	**Enduring Understanding**	**Essential Questions**
Ionic compounds should be in an aqueous state to react.	Why do aqueous reactions occur? C12-1-07	Scientific inquiry requires the use of specific skills developed along a continuum.	How would you use scientific inquiry in everyday life? C12-0-S2 C12-0-S9 C12-0-S3 C12-0-A1	Science and technology drive the economy.	How do the applications of chemistry affect our economy? C12-0-T1 C12-0-T2 C12-0-T3
Some ionic aqueous compounds will form a precipitate, gas, water or not react.	How do you know when a precipitate will form? C12-1-01, C12-1-02 C12-1-03	The scientific inquiry process is cyclic with certain steps that can be revisited and is open to improvement.	How do you know that you conducted a fair test? C12-0-S6 C12-0-S8 C12-0-A2	Modern scientific understandings are influenced by historical models and research.	How do historical models and research influence recent developments in science? C12-0-N1 C12-0-N2 C12-0-N3
	Why are some reactions spontaneous and not others?	Chemical inquiry demonstrates a sensitivity towards the environment.	How do you estimate, collect, record, organize, and display data using an appropriate format? C12-0-S5 C12-0-S8 C12-0-S6 C12-0-S9 C12-0-S7	Scientific research should consider the science, technology, society, and environment in any situation.	How do you conduct appropriate and valid research? C12-0-R1 C12-0-R5 C12-0-R2 C12-0-C2 C12-0-R3 C12-0-R4

(Page 2) Knowledge and Understanding		Scientific Inquiry	Scientific Inquiry S, C1, A1, A2	Process and Design & STSE	Process and Design & STSE: R, C2, C3, D, A1, A2, A3, A4
Enduring Understanding	**Essential Questions**	**Enduring Understanding**	**Essential Questions**	**Enduring Understanding**	**Essential Questions**
Increase in entropy and decrease in enthalpy drive all reactions.	How are entropy and enthalpy related to chemical reactions?		How do you demonstrate appropriate work habits and consideration for the environment? C12-0-S1 C12-0-C2 C12-0-S4 C12-0-C3 C12-0-C1	Effective decision-making requires careful consideration of a number of factors.	How do you use scientific research to make an informed decision? C12-0-D1 C12-0-D5 C12-0-D2 C12-0-D6 C12-0-D3 C12-0-A4 C12-0-D4
	Why do substances react? C12-1-04 C12-1-05 C12-1-06		Why is lab safety important? How do you know that you are working safely? C12-0-S1	Scientific literacy is necessary to understand local and global issues.	How does scientific literacy affect your everyday life? C12-0-A1 C12-0-A2 C12-0-A3 C12-0-A4
	How do you predict possible products in a chemical reaction?	People must work together to achieve common goals.	What strategies must people employ to work together to achieve a common goal? C12-0-C1 C12-0-C2 C12-0-C3		
Redox reactions have practical implications to aqueous reactions.	How do redox reactions affect aqueous solutions? C12-1-07 to C12-1-12				
	How can you represent chemical concepts? C12-0-U1 C12- 0-U2				

Topic 2: Atomic Structure

Essential Vocabulary: electromagnetic spectrum, frequency, wavelength, energy, line spectra, Quantum Mechanical Model, electron configurations, atomic radii, ionic radii, ionization energy, electronegativity, periodic trend

Knowledge and Understanding		**Scientific Inquiry**	**Scientific Inquiry S, C1, A1, A2**	**Process and Design & STSE**	**Process and Design & STSE: R, C2, C3, D, A1, A2, A3, A4**
Enduring Understanding	**Essential Questions**	**Enduring Understanding**	**Essential Questions**	**Enduring Understanding**	**Essential Questions**
Each element has its own set of unique characteristics that identify it.	Why are elements unique? C12-2-01 C12-2-02 C12-2-03 C12-2-04	Scientific inquiry requires the use of specific skills developed along a continuum	How would you use scientific inquiry in everyday life? C12-0-S2 C12-0-S9 C12-0-S3 C12-0-A1	Science and technology drive the economy.	How do the applications of chemistry affect our economy? C12-0-T1 C12-0-T2 C12-0-T3
The periodic table has trends, patterns, and models the structure of elements.	How is the periodic table a useful tool? C12-2-05 C12- 2-06 C12-2-07	The scientific inquiry process is cyclic with certain steps that can be revisited and is open to improvement.	How do you know that you conducted a fair test? C12-0-S6 C12-0-S8 C12-0-A2	Modern scientific understandings are influenced by historical models and research.	How do historical models and research influence recent developments in science? C12-0-N1 C12-0-N2 C12-0-N3
Nuclear charge and electron shielding effect determine the trends and patterns on the periodic table, as well as electron configuration.	How do nuclear change and electron shielding effect, influence electron structure and periodic trends? C12-2-05 C12-2-06 C12-2-07	Chemical inquiry demonstrates a sensitivity towards the environment.	How do you estimate, collect, record, organize, and display data using an appropriate format? C12-0-S5 C12-0-S8 C12-0-S6 C12-0-S9 C12-0-S7	Scientific research should consider the science, technology, society, and environment in any situation.	How do you conduct appropriate and valid research? C12-0-R1 C12-0-R5 C12-0-R2 C12-0-C2 C12-0-R3 C12-0-R4
	How can you represent chemical concepts? C12-0-U1 C12-0-U2		How do you demonstrate appropriate work habits and consideration for the environment? C12-0-S1 C12-0-C2 C12-0-S4 C12-0-C3 C12-0-C1	Effective decision-making requires careful consideration of a number of factors.	How do you use scientific research to make an informed decision? C12-0-D1 C12-0-D5 C12-0-D2 C12-0-D6 C12-0-D3 C12-0-A4 C12-0-D4

(Page 2) Knowledge and Understanding		Scientific Inquiry	Scientific Inquiry S, C1, A1, A2	Process and Design & STSE	Process and Design & STSE: R, C2, C3, D, A1, A2, A3, A4
Enduring Understanding	**Essential Questions**	**Enduring Understanding**	**Essential Questions**	**Enduring Understanding**	**Essential Questions**
			Why is lab safety important? How do you know that you are working safely? C12-0-S1	Scientific literacy is necessary to understand local and global issues.	How does scientific literacy affect your everyday life? C12-0-A1 C12-0-A2 C12-0-A3 C12-0-A4
			What strategies must people employ to work together to achieve a common goal? C12-0-C1 C12- 0-C2 C12-0-C3		

Topic 3: Kinetics

Essential Vocabulary: reaction rate, initial rate, average rate, instantaneous rate, nature of reactants, surface area, concentration, pressure, volume, temperature, catalyst, Collision Theory, activation energy, orientation of molecules, endothermic, exothermic, enthalpy change, activated complex, potential energy diagrams, heat of reaction, rate determining step, reaction mechanism, zero order, first order, second order, concentration graphs

Knowledge and Understanding		**Scientific Inquiry**	**Scientific Inquiry S, C1, A1, A2**	**Process and Design & STSE**	**Process and Design & STSE: R, C2, C3, D, A1, A2, A3, A4**
Enduring Understanding	**Essential Questions**	**Enduring Understanding**	**Essential Questions**	**Enduring Understanding**	**Essential Questions**
Chemical reactions can occur at different rates, or not at all.	Why do chemical reactions occur at different rates? C12-3-01 C12-3-03 C12-3-04	Scientific inquiry requires the use of specific skills developed along a continuum.	How would you use scientific inquiry in everyday life? C12-0-S2 C12-0-S9 C12-0-S3 C12-0-A1	Science and technology drive the economy.	How do the applications of chemistry affect our economy? C12-0-T1 C12-0-T2 C12-0-T3
A variety of factors can affect the rate of a reaction.	How are reaction rates affected by, surface area, concentration, temperature, nature to reactants, catalysts? C12-3-02 C12-3-04 C12-3-05 C12-3-06	The scientific inquiry process is cyclic with certain steps that can be revisited and is open to improvement	How do you know that you conducted a fair test? C12-0-S6 C12-0-S8 C12-0-A2	Modern scientific understandings are influenced by historical models and research.	How do historical models and research influence recent developments in science? C12-0-N1 C12-0-N2 C12-0-N3
	How does the collision theory explain chemical kinetics? C12-3-06	Chemical inquiry demonstrates a sensitivity towards the environment.	How do you estimate, collect, record, organize, and display data using an appropriate format? C12-0-S5 C12-0-S8 C12-0-S6 C12-0-S9 C12-0-S7	Scientific research should consider the science, technology, society, and environment in any situation.	How do you conduct appropriate and valid research? C12-0-R1 C12-0-R5 C12-0-R2 C12-0-C2 C12-0-R3 C12-0-R4

(Page 2) Knowledge and Understanding		Scientific Inquiry	Scientific Inquiry S, C1, A1, A2	Process and Design & STSE	Process and Design & STSE: R, C2, C3, D, A1, A2, A3, A4
Enduring Understanding	**Essential Questions**	**Enduring Understanding**	**Essential Questions**	**Enduring Understanding**	**Essential Questions**
	How do reaction mechanisms affect reaction rates? C12-3-08 C12-3-09		How do you demonstrate appropriate work habits and consideration for the environment? C12-0-S1 C12-0-C2 C12-0-S4 C12-0-C3 C12-0-C1	Effective decision-making requires careful consideration of a number of factors.	How do you use scientific research to make an informed decision? C12-0-D1 C12-0-D5 C12-0-D2 C12-0-D6 C12-0-D3 C12-0-A4 C12-0-D4
All chemical reactions involve a change in energy.	How does a change in energy affect chemical reactions? C12-3-07		Why is lab safety important? How do you know that you are working safely? C12-0-S1	Scientific literacy is necessary to understand local and global issues.	How does scientific literacy affect your everyday life? C12-0-A1 C12-0-A2 C12-0-A3 C12-0-A4
	How is experimental data related to rate law? C12-3-10		What strategies must people employ to work together to achieve a common goal? C12-0-C1 C12-0-C2 C12-0-C3		
	How can you represent chemical concepts? C12-0-U1 C12-0-U2				

Topic 4: Equilibrium

Essential Vocabulary: equilibrium, equilibrium law expression, equilibrium constant, heterogeneous, homogeneous, ICE Table Method, BIR/PEC Accounting Method, Le Chatelier's Principle, shift in equilibrium, solubility product expression (Ksp), common ion expression (Qsp)

Knowledge and Understanding		**Scientific Inquiry**	**Scientific Inquiry S, C1, A1, A2**	**Process and Design & STSE**	**Process and Design & STSE: R, C2, C3, D, A1, A2, A3, A4**
Enduring Understanding	**Essential Questions**	**Enduring Understanding**	**Essential Questions**	**Enduring Understanding**	**Essential Questions**
Chemical reactions will seek an equilibrium or a completion.	How, why and when do chemical reactions reach chemical equilibrium? C12-4-01	Scientific inquiry requires the use of specific skills developed along a continuum	How would you use scientific inquiry in everyday life? C12-0-S2 C12-0-S9 C12-0-S3 C12-0-A1	Science and technology drive the economy	How do the applications of chemistry affect our economy? C12-0-T1 C12-0-T2 C12-0-T3
Chemical equilibrium will be influenced by a variety of factors.	How do the following factors influence chemical equilibrium: concentration, temperature, pressure, and catalysts? C12-4-06 C12-4-07 C12-4-08 C12-4-09	The scientific inquiry process is cyclic with certain steps that can be revisited and is open to improvement.	How do you know that you conducted a fair test? C12-0-S6 C12-0-S8 C12-0-A2	Modern scientific understandings are influenced by historical models and research.	How do historical models and research influence recent developments in science? C12-0-N1 C12-0-N2 C12-0-N3
	How can Le Chatelier's principle be applied in everyday life? C12-4-06 C12-4-07 C12-4-08 C12-4-09	Chemical inquiry demonstrates a sensitivity towards the environment.	How do you estimate, collect, record, organize, and display data using an appropriate format? C12-0-S5 C12-0-S8 C12-0-S6 C12-0-S9 C12-0-S7	Scientific research should consider the science, technology, society, and environment in any situation.	How do you conduct appropriate and valid research? C12-0-R1 C12-0-R5 C12-0-R2 C12-0-C2 C12-0-R3 C12-0-R4

(Page 2) Knowledge and Understanding		Scientific Inquiry	Scientific Inquiry S, C1, A1, A2	Process and Design & STSE	Process and Design & STSE: R, C2, C3, D, A1, A2, A3, A4
Enduring Understanding	**Essential Questions**	**Enduring Understanding**	**Essential Questions**	**Enduring Understanding**	**Essential Questions**
Equilibrium can be quantified.	How do you apply Keq and Ksp to equilibrium systems? C12-4-02 C12-4-03 C12-4-04 C12-4-05 C12-4-10 C12-4-11 C12-4-12 C12-4-13		How do you demonstrate appropriate work habits and consideration for the environment? C12-0-S1 C12-0-C2 C12-0-S4 C12-0-C3 C12-0-C1	Effective decision-making requires careful consideration of a number of factors.	How do you use scientific research to make an informed decision? C12-0-D1 C12-0-D5 C12-0-D2 C12-0-D6 C12-0-D3 C12-0-A4 C12-0-D4
	How can you represent chemical concepts? C12-0-U1 C12-0-U2		Why is lab safety important? How do you know that you are working safely? C12-0-S1	Scientific literacy is necessary to understand local and global issues.	How does scientific literacy affect your everyday life? C12-0-A1 C12-0-A2 C12-0-A3 C12-0-A4
			What strategies must people employ to work together to achieve a common goal? C12-0-C1 C12-0-C2 C12-0-C3		

Topic 5: Acids and Bases

Essential Vocabulary: Arrhenius, Bronsted-Lowry, Lewis, conjugate acid/base pairs, amphoteric behaviour, hydronium ion, ion product constant (K_w), pH, pOH, acid/base indicator, electrolyte, non-electrolyte, K_a, K_b, standardized acid, standardized base, acid solution, basic solution, neutral solution, salt, neutralization, titration, end point, titration curve

Knowledge and Understanding		**Scientific Inquiry**	**Scientific Inquiry S, C1, A1, A2**	**Process and Design & STSE**	**Process and Design & STSE: R, C2, C3, D, A1, A2, A3, A4**
Enduring Understanding	**Essential Questions**	**Enduring Understanding**	**Essential Questions**	**Enduring Understanding**	**Essential Questions**
Acids and bases have identifiable characteristics (strong/weak, conc./dilute).	How do you identify an acid or base? C12-5-07 C12-5-11	Scientific inquiry requires the use of specific skills developed along a continuum.	How would you use scientific inquiry in everyday life? C12-0-S2 C12-0-S9 C12-0-S3 C12-0-A1	Science and technology drive the economy.	How do the applications of chemistry affect our economy? C12-0-T1 C12-0-T2 C12-0-T3
There are multiple definitions for acids or bases (can be defined in various ways).	How are acids and bases defined? C12-5-01	The scientific inquiry process is cyclic with certain steps that can be revisited and is open to improvement.	How do you know that you conducted a fair test? C12-0-S6 C12-0-S8 C12-0-A2	Modern scientific understandings are influenced by historical models and research.	How do historical models and research influence recent developments in science? C12-0-N1 C12-0-N2 C12-0-N3
	How do you qualify and quantify acids & bases? C12-5-03 C12-5-04 C12-5-05 C12-5-10	Chemical inquiry demonstrates a sensitivity towards the environment.	How do you estimate, collect, record, organize, and display data using an appropriate format? C12-0-S5 C12-0-S8 C12-0-S6 C12-0-S9 C12-0-S7	Scientific research should consider the science, technology, society, and environment in any situation	How do you conduct appropriate and valid research? C12-0-R1 C12-0-R5 C12-0-R2 C12-0-C2 C12-0-R3 C12-0-R4

(Page 2) Knowledge and Understanding		Scientific Inquiry	Scientific Inquiry S, C1, A1, A2	Process and Design & STSE	Process and Design & STSE: R, C2, C3, D, A1, A2, A3, A4
Enduring Understanding	**Essential Questions**	**Enduring Understanding**	**Essential Questions**	**Enduring Understanding**	**Essential Questions**
	How do acids react with bases? C12-5-02		How do you demonstrate appropriate work habits and consideration for the environment? C12-0-S1 C12-0-C2 C12-0-S4 C12-0-C3 C12-0-C1	Effective decision-making requires careful consideration of a number of factors.	How do you use scientific research to make an informed decision? C12-0-D1 C12-0-D5 C12-0-D2 C12-0-D6 C12-0-D3 C12-0-A4 C12-0-D4
	How do you apply Ka and Kb to equilibrium systems? C12-5-08 C12-5-09		Why is lab safety important? How do you know that you are working safely? C12-0-S1	Scientific literacy is necessary to understand local and global issues.	How does scientific literacy affect your everyday life? C12-0-A1 C12-0-A2 C12-0-A3 C12-0-A4
Acid-base equilibrium systems are found in the environment and biological systems.	Where do you find acid-base systems in everyday life?		What strategies must people employ to work together to achieve a common goal? C12-0-C1 C12-0-C2 C12-0-C3		
Acid-base reactions can be quantified experimentally.	How can you determine acid-base concentrations experimentally? C12-5-10				
	How can you represent chemical concepts? C12-0-U1				

Topic 6: Electrochemistry

Essential Vocabulary: activity series, standard oxidation potentials, standard reduction potentials, spontaneity of reactions, voltaic (galvanic) cells, half-cell reactions, standard electrical potential (voltage), standard potential, electrolytic cells, electrodes, electrolysis, electroplating, salt bridge, Faraday's Law, polarization

Knowledge and Understanding		**Scientific Inquiry**	**Scientific Inquiry S, C1, A1, A2**	**Process and Design & STSE**	**Process and Design & STSE: R, C2, C3, D, A1, A2, A3, A4**
Enduring Understanding	**Essential Questions**	**Enduring Understanding**	**Essential Questions**	**Enduring Understanding**	**Essential Questions**
Spontaneous redox reactions involve electron transfer.	How are redox reactions identifiable?	Scientific inquiry requires the use of specific skills developed along a continuum	How would you use scientific inquiry in everyday life? C12-0-S2 C12-0-S9 C12-0-S3 C12-0-A1	Science and technology drive the economy	How do the applications of chemistry affect our economy? C12-0-T1 C12-0-T2 C12-0-T3
	How do you determine oxidation state?	The scientific inquiry process is cyclic with certain steps that can be revisited and is open to improvement.	How do you know that you conducted a fair test? C12-0-S6 C12-0-S8 C12-0-A2	Modern scientific understandings are influenced by historical models and research.	How do historical models and research influence recent developments in science? C12-0-N1 C12-0-N2 C12-0-N3
	How do you balance redox reactions?	Chemical inquiry demonstrates a sensitivity towards the environment.	How do you estimate, collect, record, organize, and display data using an appropriate format? C12-0-S5 C12-0-S8 C12-0-S6 C12-0-S9 C12-0-S7	Scientific research should consider the science, technology, society, and environment in any situation.	How do you conduct appropriate and valid research? C12-0-R1 C12-0-R5 C12-0-R2 C12-0-C2 C12-0-R3 C12-0-R4

(Page 2) Knowledge and Understanding		Scientific Inquiry	Scientific Inquiry S, C1, A1, A2	Process and Design & STSE	Process and Design & STSE: R, C2, C3, D A1, A2, A3, A4
Enduring Understanding	**Essential Questions**	**Enduring Understanding**	**Essential Questions**	**Enduring Understanding**	**Essential Questions**
Electrons travel from high potential to low potential resulting in a physical change.	How do you use reduction potential to determine spontaneity of redox reactions? C12-6-01 C12-6-02 C12-6-06 C12-6-07		How do you demonstrate appropriate work habits and consideration for the environment? C12-0-S1 C12-0-C2 C12-0-S4 C12-0-C3 C12-0-C1	Effective decision-making requires careful consideration of a number of factors.	How do you use scientific research to make an informed decision? C12-0-D1 C12-0-D5 C12-0-D2 C12-0-D6 C12-0-D3 C12-0-A4 C12-0-D4
	How do electrochemical cells work and how are they used? C12-6-10 C12-6-11		Why is lab safety important? How do you know that you are working safely? C12-0-S1	Scientific literacy is necessary to understand local and global issues.	How does scientific literacy affect your everyday life? C12-0-A1 C12-0-A2 C12-0-A3 C12-0-A4
	How do electrochemical cells produce voltage (current)? C12-6-04 C12-6-05 C12-6-06		What strategies must people employ to work together to achieve a common goal? C12-0-C1 C12-0-C2 C12-0-C3		
	How do voltaic and electrolytic cells compare? C12-6-03 C12-6-09 C12-6-12				
	How can you represent chemical concepts? C12-0-U1 C12-0-U2				

Appendix 1
Grade 11 Chemistry Grade Book Sample

Grade 11 Chemistry
nit : Properties of Matter

Enduring Understandings
The Kinetic Molecular Theory (KMT) explains physical properties of matter.

Knowledge and Understanding

Essential Questions
-How are the physical properties of matter related to the KMT?
-What does the KMT reveal about the properties of gases?
-How does the KMT explain the processes of evaporation and condensation?
-Explain the properties of liquids and solids using the KMT.
-How do you operationally define the normal boiling point and vapour pressure of a substance?

Scientific Inquiry

Essential Questions
-How would you use scientific inquiry in everyday life?
-How do you demonstrate appropriate work habits and consideration for the environment?
-How do you know that you conducted a fair test?
-How do you estimate, collect, record, organize, and display data using an appropriate format?
-Why is lab safety important?
-How do you know that you are working safely?

Problem Solving and Design

Essential Questions
-How do you conduct appropriate and valid research?
-How do you use scientific research to make an informed decision?
-How does scientific literacy affect your everyday life?

	Formativ	Evidence from Assessments					Overall Level	from Assessments					Overall Level	from Assessments					Overall Level	Student
STUDENT	Summati	Assess 1	Assess 2	Assess 3	Assess 4	Assess 5		Assess 6	Assess 7	Assess 8	Assess 9	Assess 10		Assess 1	Assess 1	Assess 1	Assess 1	Assess 15		
Joe Smith		1	4	1	1	2	1	2	2	3	2	2	2	1	3	3	2	3	3	Joe Smith
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ASSESSMENTS

1	Lab 1	6		11	
2	Lab 2	7		12	
3	Questions 1-4 pg 17	8		13	
4	Quiz #1	9		14	
5	Lab 3	10		15	

Appendix 2
Grade 11 Chemistry GLOs and SLOs

General Learning Outcomes

General learning outcomes (GLOs) provide connections to the Five Foundations for Science 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

Cluster 0 in Grade 11 Chemistry 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 11 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 5) 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

C11-0-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…
C11-0-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

C11-0-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), emergency equipment
C11-0-S2 State a testable hypothesis or prediction based on background data or on observed events.

C11-0-S3 Design and implement an investigation to answer a specific scientific question. Include: materials, independent and dependent variables, controls, methods, safety considerations
C11-0-S4 Select and use scientific equipment appropriately and safely.bExamples: volumetric glassware, balance, thermometer…
C11-0-S5 Collect, record, organize, and display data using an appropriate format. Examples: labelled diagrams, graphs, multimedia applications, software integration, probeware…
C11-0-S6 Estimate and measure accurately using Système International (SI) and other standard units. Include: SI conversions, significant figures
C11-0-S7 Interpret patterns and trends in data, and infer and explain relationships.
C11-0-S8 Evaluate data and data-collection methods for accuracy and precision. Include: discrepancies in data, sources of error, percent error
C11-0-S9 Draw a conclusion based on the analysis and interpretation of data. Include: cause-and-effect relationships, alternative explanations, supporting or rejecting a hypothesis or prediction

Research
C11-0-R1 Synthesize information obtained from a variety of sources. Include: print and electronic sources, specialists, other resource people
C11-0-R2 Evaluate information obtained to determine its usefulness for information needs. Examples: scientific accuracy, reliability, currency, relevance, balance of perspectives, bias…
C11-0-R3 Quote from or refer to sources as required and reference information sources according to an accepted practice.
C11-0-R4 Compare diverse perspectives and interpretations in the media and other information sources.
C11-0-R5 Communicate information in a variety of forms appropriate to the audience, purpose, and context.

Communication and Teamwork
C11-0-C1 Collaborate with others to achieve group goals and responsibilities.
C11-0-C2 Elicit, clarify, and respond to questions, ideas, and diverse points of view in discussions.
C11-0-C3 Evaluate individual and group processes.

Decision Making
C11-0-D1 Identify and explore a current STSE issue. Examples: clarify what the issue is, identify different viewpoints and/or stakeholders, research existing data/information…
C11-0-D2 Evaluate implications of possible alternatives or positions related to an STSE issue. Examples: positive and negative consequences of a decision, strengths and weaknesses of a position…
C11-0-D3 Recognize that decisions reflect values and consider their own values and those of others when making a decision. Examples: being in balance with nature, generating wealth, respecting personal freedom…
C11-0-D4 Recommend an alternative or identify a position and provide justification.
C11-0-D5 Propose a course of action related to an STSE issue.
C11-0-D6 Reflect on the process used by self or others to arrive at an STSE decision.

Attitudes
C11-0-A1 Demonstrate confidence in their ability to carry out investigations in chemistry and to address STSE-related issues.
C11-0-A2 Value skepticism, honesty, accuracy, precision, perseverance, and open mindedness as scientific and technological habits of mind.
C11-0-A3 Demonstrate a continuing, increasingly informed interest in chemistry and chemistry-related careers and issues.
C11-0-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 11 Chemistry. These statements clearly define what students are expected to achieve and/or be able to perform at the end of course. These SLOs, combined with the Skills and Attitudes SLOs, constitute the source upon which assessment and instructional design are based.

Topic 1: Physical Properties of Matter

C11-1-01 Describe the properties of gases, liquids, solids, and plasma. Include: density, compressibility, diffusion
C11-1-02 Use the Kinetic Molecular Theory to explain properties of gases. Include: random motion, intermolecular forces, elastic collisions, average kinetic energy, temperature
C11-1-03 Explain the properties of liquids and solids using the Kinetic Molecular Theory.
C11-1-04 Explain the process of melting, solidification, sublimation, and deposition in terms of the Kinetic Molecular Theory. Include: freezing point, exothermic, endothermic
C11-1-05 Use the Kinetic Molecular Theory to explain the processes of evaporation and condensation. Include: intermolecular forces, random motion, volatility, dynamic equilibrium
C11-1-06 Operationally define vapour pressure in terms of observable and measurable properties.
C11-1-07 Operationally define normal boiling point temperature in terms of vapour pressure.
C11-1-08 Interpolate and extrapolate the vapour pressure and boiling temperature of various substances from pressure versus temperature graphs.

Topic 2: Gases and the Atmosphere

C11-2-01 Identify the abundances of the naturally occurring gases in the atmosphere and examine how these abundances have changed over geologic time. Include: oxygenation of Earth's atmosphere, the role of biota in oxygenation, changes in carbon dioxide content over time
C11-2-02 Research Canadian and global initiatives to improve air quality.
C11-2-03 Examine the historical development of the measurement of pressure. Examples: the contributions of Galileo Galilei, Evangelista Torricelli, Otto von Guericke, Blaise Pascal, Christiaan Huygens, John Dalton, Joseph Louis Gay-Lussac, Amadeo Avogadro…
C11-2-04 Describe the various units used to measure pressure. Include: atmospheres (atm), kilopascals (kPa), millimetres of mercury (mmHg), millibars (mb)
C11-2-05 Experiment to develop the relationship between the pressure and volume of a gas using visual, numeric, and graphical representations. Include: historical contributions of Robert Boyle
C11-2-06 Experiment to develop the relationship between the volume and temperature of a gas using visual, numeric, and graphical representations. Include: historical contributions of Jacques Charles, the determination of absolute zero, the Kelvin temperature scale
C11-2-07 Experiment to develop the relationship between the pressure and temperature of a gas using visual, numeric, and graphical representations. Include: historical contributions of Joseph Louis Gay-Lussac
C11-2-08 Solve quantitative problems involving the relationships among the pressure, temperature, and volume of a gas using dimensional analysis. Include: symbolic relationships
C11-2-09 Identify various industrial, environmental, and recreational applications of gases. Examples: self-contained underwater breathing apparatus (scuba), anaesthetics, air bags, acetylene welding, propane appliances, hyperbaric chambers…

Topic 3: Chemical Reactions

C11-3-01 Determine average atomic mass using isotopes and their relative abundance. Include: atomic mass unit (amu)
C11-3-02 Research the importance and applications of isotopes. Examples: nuclear medicine, stable isotopes in climatology, dating techniques…
C11-3-03 Write formulas and names for polyatomic compounds using International Union of Pure and Applied Chemistry (IUPAC) nomenclature.
C11-3-04 Calculate the mass of compounds in atomic mass units.
C11-3-05 Write and classify balanced chemical equations from written descriptions of reactions. Include: polyatomic ions

C11-3-06 Predict the products of chemical reactions, given the reactants and type of reaction. Include: polyatomic ions
C11-3-07 Describe the concept of the mole and its importance to measurement in chemistry.
C11-3-08 Calculate the molar mass of various substances.
C11-3-09 Calculate the volume of a given mass of a gaseous substance from its density at a given temperature and pressure. Include: molar volume calculation
C11-3-10 Solve problems requiring interconversions between moles, mass, volume, and number of particles.
C11-3-11 Determine empirical and molecular formulas from percent composition or mass data.
C11-3-12 Interpret a balanced equation in terms of moles, mass, and volumes of gases.
C11-3-13 Solve stoichiometric problems involving moles, mass, and volume, given the reactants and products in a balanced chemical reaction. Include: heat of reaction problems
C11-3-14 Identify the limiting reactant and calculate the mass of a product, given the reaction equation and reactant data.
C11-3-15 Perform a lab involving mass-mass or mass-volume relations, identifying the limiting reactant and calculating the mole ratio. Include: theoretical yield, experimental yield
C11-3-16 Discuss the importance of stoichiometry in industry and describe specific applications. Examples: analytical chemistry, chemical engineering, industrial chemistry…

Topic 4: Solutions
C11-4-01 Describe and give examples of various types of solutions. Include: all nine possible types
C11-4-02 Describe the structure of water in terms of electronegativity and the polarity of its chemical bonds.
C11-4-03 Explain the solution process of simple ionic and covalent compounds, using visual, particulate representations and chemical equations. Include: crystal structure, dissociation, hydration
C11-4-04 Explain heat of solution with reference to specific applications. Examples: cold packs, hot packs…
C11-4-05 Perform a lab to illustrate the formation of solutions in terms of the polar and non-polar nature of substances. Include: soluble, insoluble, miscible, immiscible
C11-4-06 Construct, from experimental data, a solubility curve of a pure substance in water.
C11-4-07 Differentiate among saturated, unsaturated, and supersaturated solutions.
C11-4-08 Use a graph of solubility data to solve problems.
C11-4-09 Explain how a change in temperature affects the solubility of gases.
C11-4-10 Explain how a change in pressure affects the solubility of gases.
C11-4-11 Perform a lab to demonstrate freezing-point depression and boiling-point elevation.
C11-4-12 Explain freezing-point depression and boiling-point elevation at the molecular level. Examples: antifreeze, road salt…
C11-4-13 Differentiate among, and give examples of, the use of various representations of concentration. Include: grams per litre (g/L), % weight-weight (% w/w), % weight-volume (% w/v), % volume/volume (% v/v), parts per million (ppm), parts per billion (ppb), moles per litre (mol/L) (molarity)
C11-4-14 Solve problems involving calculation for concentration, moles, mass, and volume.
C11-4-15 Prepare a solution, given the amount of solute(in grams) and the volume of solution(in millilitres), and determine concentration in moles/litre.
C11-4-16 Solve problems involving the dilution of solutions. Include: dilution of stock solutions, mixing common solutions with different volumes and concentrations
C11-4-17 Perform a dilution from a solution of known concentration.
C11-4-18 Describe examples of situations where solutions of known concentration are important. Examples: pharmaceutical preparations, administration of drugs, aquaria, swimming pool disinfectants, gas mixes for scuba, radiator antifreeze
C11-4-19 Describe the process of treating a water supply, identifying the allowable concentrations of metallic and organic species suitable for consumption.

Topic 5: Organic Chemistry
C11-5-01 Compare and contrast inorganic and organic chemistry. Include: the contributions of Friedrich Wöhler to the overturn of vitalism
C11-5-02 Identify the origins and major sources of hydrocarbons and other organic compounds. Include: natural and synthetic sources
C11-5-03 Describe the structural characteristics of carbon Include: bonding characteristics of the carbon atom in hydrocarbons (single, double, triple bonds)
C11-5-04 Compare and contrast the molecular structures of alkanes, alkenes, and alkynes. Include: trends in melting points and boiling points of alkanes only

C11-5-05 Name, draw, and construct structural models of the first 10 alkanes. Include: IUPAC nomenclature, structural formulas, condensed structural formulas, molecular formulas, general formula CnH(2n+2)
C11-5-06 Name, draw, and construct structural models of branched alkanes. Include: six-carbon parent chain, methyl and ethyl substituent groups, IUPAC nomenclature
C11-5-07 Name, draw, and construct structural models of isomers for alkanes up to six-carbon atoms. Include: condensed structural formulas
C11-5-08 Outline the transformation of alkanes to alkenes and vice versa. Include: dehydrogenation/hydrogenation, molecular models
C11-5-09 Name, draw, and construct molecular models of alkenes and branched alkenes. Include: six-carbon parent chain, methyl and ethyl substituent groups, IUPAC nomenclature, structural formulas, condensed structural formulas, molecular formulas, general formula CnH2n
C11-5-10 Differentiate between saturated and unsaturated hydrocarbons.
C11-5-11 Outline the transformation of alkenes to alkynes and vice versa. Include: dehydrogenation/hydrogenation, molecular models
C11-5-12 Name, draw, and construct structural models of alkynes and branched alkynes. Include: six-carbon parent chain, methyl and ethyl substituent groups, IUPAC nomenclature, structural formulas, condensed structural formulas, molecular formulas, general formula CnH2n-2
C11-5-13 Compare and contrast the structure of aromatic and aliphatic hydrocarbons. Include: molecular models, condensed structural formulas
C11-5-14 Describe uses of aromatic hydrocarbons. Examples: polychlorinated biphenyls, caffeine, steroids, organic solvents (toluene, xylene)…
C11-5-15 Write condensed structural formulas for and name common alcohols. Include: maximum of six-carbon parent chain, IUPAC nomenclature
C11-5-16 Describe uses of methyl, ethyl, and isopropyl alcohols.
C11-5-17 Write condensed structural formulas for and name organic acids. Include: maximum of six-carbon parent chain, IUPAC nomenclature
C11-5-18 Describe uses or functions of common organic acids. Examples: acetic, ascorbic, citric, formic, acetylsalicylic (ASA), lactic…
C11-5-19 Perform a lab involving the formation of esters, and examine the process of esterification.
C11-5-20 Write condensed structural formulas for and name esters. Include: up to 6-C alcohols and 6-C organic acids, IUPAC nomenclature
C11-5-21 Describe uses of common esters. Examples: pheromones, artificial flavourings…
C11-5-22 Describe the process of polymerization and identify important natural and synthetic polymers. Examples: polyethylene, polypropylene, polystyrene, polytetrafluoroethylene (Teflon®)…
C11-5-23 Describe how the products of organic chemistry have influenced quality of life. Examples: synthetic rubber, nylon, medicines, polytetrafluoroethylene (Teflon®)…
C11-5-24 Use the decision-making process to investigate an issue related to organic chemistry. Examples: gasohol production, alternative energy sources, recycling of plastics…

Appendix 3
Grade 12 Chemistry GLOs and SLOs

General Learning Outcomes

General learning outcomes (GLOs) provide connections to the Five Foundations for Science 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)

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
Cluster 0 in Grade 12 Chemistry 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 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 openmindedness 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 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 (18 hours)

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 (10 hours)

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

Topic 3: Chemical Kinetics (10 hours)

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, D*x*/D*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 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: reactions that are zero, first, or second order and reaction rate versus concentration graphs

Topic 4: Chemical Equilibrium (17 hours)

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 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 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 (14.5 hours)

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, using a standardized acid or base.
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 (14.5 hours)

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 short-hand (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.

Grade 11/12 Chemistry Definitions –
Provincial Report Card Categories

Knowledge and Understanding

This report card category focuses on student progress related to learning experiences in which students demonstrate understanding of grade-specific science concepts.

Scientific Inquiry

This report card category focuses on student progress related to learning experiences in which students ask questions, generate possible explanations, collect and analyze evidence, and reach conclusions based on evidence. Scientific inquiry also involves the use of the science process skills, including: questioning, observing, classifying, measuring, communicating, inferring, predicting, hypothesizing, experimenting; and collecting, analyzing, and interpreting data.

Design Process/Problem Solving

This report card category focuses on student progress related to learning experiences in which students apply science knowledge to seek solutions to practical problems. Students solve scientific problems and/or use the steps related to the design process. The design process steps are:

1. Identify a need
2. Create a plan
3. Develop a product
4. Communicate the results.

The design process includes the proposing, creating, and testing of prototypes, products, and techniques in an attempt to reach an optimal solution to a given problem.

References:
The Manitoba Report Card Support Document. Manitoba Education. 2012.
Kindergarten to Grade 4 Science: Manitoba Curriculum Framework of Outcomes. Manitoba Education. 1999.

Essential Learning Terminology

Enduring understanding
"Enduring understandings are statements summarizing important ideas and core processes that are central to a discipline and have lasting value beyond the classroom. They synthesize what students should understand….as a result of studying a particular content area. Moreover, they articulate what students should "revisit" over the course of their lifetimes in relationship to the content area."

Key performance skills
Key performance skills draw on a variety of skills. Performance skills develop within the individual and grow in sophistication over time. Some examples of key performance skills include problem solving, critical thinking and inquiry, design process etc.

Values/attitudes/dispositions
Students need to develop the values and attitudes that assist them in understanding each discipline with some depth, then knowing how to communicate their understanding while seeing the relationship between each discipline.

Essential questions
Questions that are not answerable with finality in a brief sentence…their aim is to stimulate thought, provoke inquiry and spark more questions. *Wiggins/McTighe 2005*

Concepts
The broad concept provides a frame through which students filter information *(Erickson*). When a concept is truly understood it can be explained and is transferrable, or applied to problem-solving. *Wiggins/McTighe 2005*

Essential vocabulary
Vocabulary is introduced when needed to clarify experiences and ideas rather than in a list of new terms that start the unit. Essential vocabulary consists of figurative language, nuances in word meaning, roots, affixes, context clues, dictionary, thesaurus, pronunciation, parts of speech. *Wiggins/McTighe 2005*