CHEMISTRY 20–30

PROGRAM RATIONALE AND PHILOSOPHY

Science programs provide opportunities for students to develop the knowledge, skills and attitudes they need to become productive and responsible members of society. The programs also allow students to explore interests and prepare for further education and careers. Students graduating from Alberta schools require the scientific and related technological knowledge and skills that will enable them to understand and interpret their world. They also need to develop attitudes that will motivate them to use their knowledge and skills in a responsible manner.

To become scientifically literate, students need to develop a knowledge of science and its relationship to technologies and society. They also need to develop the broad-based skills required to identify and analyze problems; to explore and test solutions; and to seek, interpret and evaluate information. To ensure relevance to students as well as to societal needs, a science program must present science in a meaningful context—providing opportunities for students to explore the process of science, its applications and implications, and to examine related technological problems and issues. By doing so, students become aware of the role of science in responding to social and cultural change and in meeting needs for a sustainable environment, economy and society.

Program Vision

The secondary science program is guided by the vision that all students, regardless of gender or cultural background, are given the opportunity to develop scientific literacy. The goal of scientific literacy is to develop in students the science-related knowledge, skills and attitudes that they need to solve problems and make decisions and, at the same time, to help students become lifelong learners who maintain their sense of wonder about the world around them.

Diverse learning experiences within the science program provide students with opportunities to explore, analyze and appreciate the interrelationships among science, technology, society and the environment and to develop understandings that will affect their personal lives, their careers and their futures.

Goals

The following goals for Canadian science education, developed in the *Common Framework of Science Learning Outcomes K to 12: Pan-Canadian Protocol for Collaboration on School Curriculum* (1997), are addressed through the Alberta science program. Science education will:

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

Aboriginal Perspectives

Courses in the senior high school sciences incorporate Aboriginal perspectives in order to develop, in all students, an appreciation of the cultural diversity and achievements of First Nations, Métis and Inuit (FNMI) peoples. These courses are designed to:

- acknowledge the contributions of Aboriginal peoples to understandings of the natural world
- support relational thinking by integrating learning from various disciplines of science
- develop the concept of humankind's connectivity to the natural world and foster an appreciation for the importance of caring for the environment
- foster the development of positive attitudes by providing experiences that encourage all students to feel confident about their ability to succeed in science.

Information and Communication Technology (ICT)

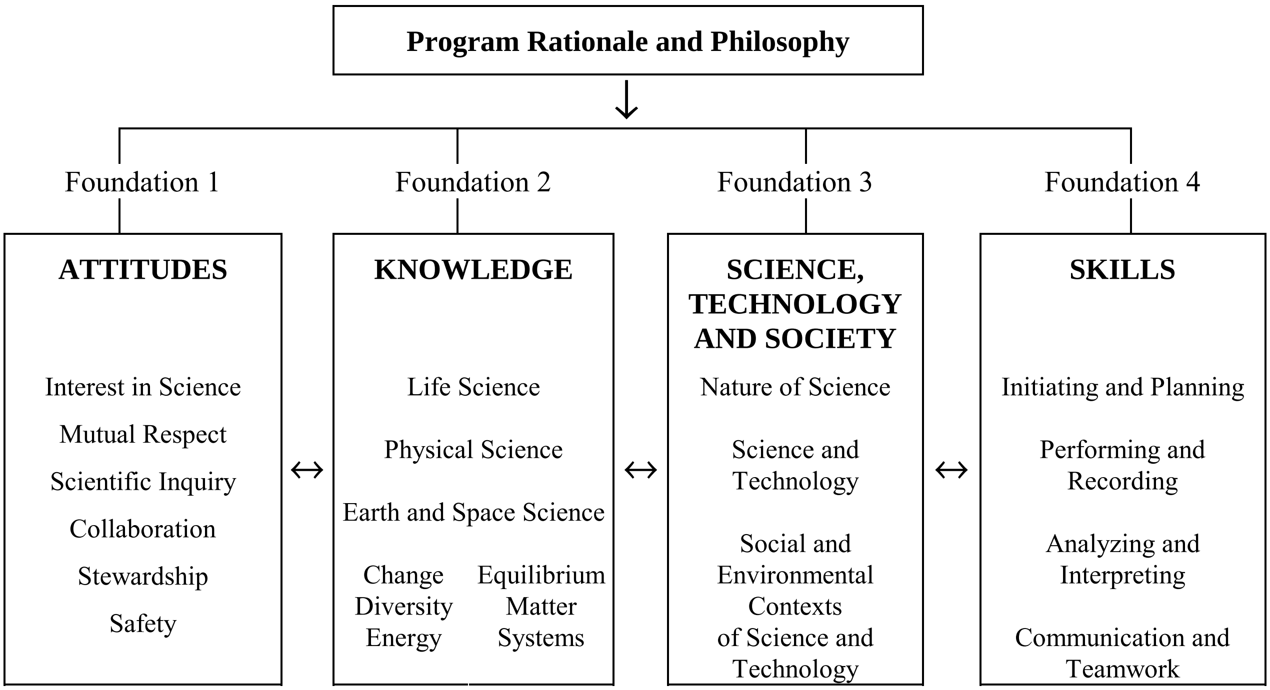
Selected curriculum outcomes from Alberta Education's Information and Communication Technology (ICT) Program of Studies are infused throughout the 20-level and 30-level sciences so that students will develop a broad perspective on the nature of technology, learn how to use and apply a variety of technologies, and consider the impact of ICT on individuals and society. The infusion of ICT outcomes supports and reinforces the understandings and abilities that students are expected to develop within Foundation 3 (Science, Technology and Society) and Foundation 4 (Skills) of these courses. Effective, efficient and ethical application of ICT outcomes contributes to the program vision.

Infusion of ICT outcomes provides learning opportunities for students to:

- understand the nature of technology and apply terminology appropriately
- use equipment carefully and share limited ICT resources
- use technology in an ethical manner, including respecting the ownership of information and digital resources and citing electronic sources
- use technology safely, including applying ergonomic principles and appropriate safety procedures
- use the Internet safely, including protecting personal information and avoiding contact with strangers
- use technology appropriately, including following communication etiquette and respecting the privacy of others.

PROGRAM FOUNDATIONS

To support the development of scientific literacy, a science program must provide learning experiences that address critical aspects of science and its application. These foundations provide a general direction for the program and identify the major components of its structure.



Foundation 1
Attitudes—*Students will be encouraged to* develop attitudes that support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society and the environment.

Foundation 2
Knowledge—*Students will* construct knowledge and understandings of concepts in life science, physical science and Earth and space science, and apply these understandings to interpret, integrate and extend their knowledge.

Foundation 3
Science, Technology and Society (STS)—*Students will* develop an understanding of the nature of science and technology, the relationships between science and technology, and the social and environmental contexts of science and technology.

Foundation 4
Skills—*Students will* develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively and for making informed decisions.

Foundation 1: Attitudes

Foundation 1 is concerned with the generalized aspects of behaviour that are commonly referred to as attitudes. Attitude outcomes are of a different form than outcomes for skills and knowledge: they are exhibited in a different way, and they are rooted more deeply in the experiences that students bring to school. Attitude development is a lifelong process that involves the home, the school, the community and society at large. Attitudes are best shown not by the events of a particular moment but by the pattern of behaviours over time. Development of positive attitudes plays an important role in student growth by interacting with students' intellectual development and by creating a readiness for responsible application of what is learned.

Interest in Science

Students will be encouraged to develop enthusiasm and continuing interest in the study of science.

Mutual Respect

Students will be encouraged to appreciate that scientific understanding evolves from the interaction of ideas involving people with different views and backgrounds.

Scientific Inquiry

Students will be encouraged to develop attitudes that support active inquiry, problem solving and decision making.

Collaboration

Students will be encouraged to develop attitudes that support collaborative activity.

Stewardship

Students will be encouraged to develop responsibility in the application of science and technology in relation to society and the natural environment.

Safety

Students will be encouraged to demonstrate a concern for safety in science and technology contexts.

Foundation 2: Knowledge

Foundation 2 focuses on the subject matter of science, including the laws, theories, models, concepts and principles that are essential to an understanding of each science area. For organizational purposes, this foundation is framed using widely accepted science disciplines.

Life Science

Life science deals with the growth and interactions of life forms within their environments in ways that reflect their uniqueness, diversity, genetic continuity and changing nature. Life science includes such fields of study as ecosystems, biological diversity, organisms, cells, biochemistry, genetic engineering and biotechnology.

Physical Science

Physical science, which encompasses chemistry and physics, deals with matter, energy and forces. Matter has structure, and there are interactions among its components. Energy links matter to gravitational, electromagnetic and nuclear forces in the universe. Physical science also addresses the conservation laws of mass and energy, momentum and charge.

Earth and Space Science

Earth and space science brings global and universal perspectives to student knowledge. The planet Earth exhibits form, structure and patterns of change, as does the surrounding solar system and the physical universe beyond it. Earth and space science includes such fields of study as geology, meteorology and astronomy.

Themes are the major ideas of science and technology that transcend discipline boundaries and demonstrate unity among the natural sciences. Six themes have been identified for the senior high school sciences program.

Change
Students will develop an understanding of:

How all natural entities are modified over time, how the direction of change might be predicted and, in some instances, how change can be controlled.

Diversity
Students will develop an understanding of:

The array of living and nonliving forms of matter and the procedures used to understand, classify and distinguish these forms of matter on the basis of recurring patterns.

Energy
Students will develop an understanding of:

The capacity for doing work that drives much of what takes place in the universe through its variety of interconvertible forms.

Equilibrium
Students will develop an understanding of:

The state in which opposing forces or processes balance in a static or dynamic way.

Matter
Students will develop an understanding of:

The constituent parts, and the variety of states, of the material in the physical world.

Systems
Students will develop an understanding of:

The interrelated groups of things or events that can be defined by their boundaries and, in some instances, by their inputs and outputs.

Foundation 3: Science, Technology and Society (STS)

Foundation 3 is concerned with understanding the scope and character of science, its connections to technology and the social context in which it is developed. The following is a brief introduction to the major ideas underlying this component of the program.

Nature of Science

Science provides an ordered way of learning about the nature of things, based on observation and evidence. Through science, we explore our environment, gather knowledge and develop ideas that help us interpret and explain what we see. Scientific activity provides a conceptual and theoretical base that is used in predicting, interpreting and explaining natural and technological phenomena. Science is driven by a combination of specific knowledge, theory, observation and experimentation. Science-based ideas are continually being tested, modified and improved as new knowledge and explanations supersede existing knowledge and explanations.

Science and Technology

Technology is concerned with solving practical problems that arise from human needs. Historically, the development of technology has been strongly linked to the development of science, with each making contributions to the other. While there are important relationships and interdependencies, there are also important differences. Whereas the focus of science is on the development and verification of knowledge, the focus of technology is on the development of solutions, involving devices and systems that meet a given need within the constraints of a problem. The test of scientific knowledge is that it helps us explain, interpret and predict; the test of technology is that it works—it enables us to achieve a given purpose.

Social and Environmental Contexts

The history of science shows that scientific development takes place within a social context. Many examples can be used to show that cultural and intellectual traditions have influenced the focus and methodologies of science, and that science in turn has influenced the wider world of ideas.

Today, research is often driven by societal and environmental needs and issues. As technological solutions have emerged from previous research, many of the new technologies have given rise to complex social and environmental issues. Increasingly, these issues are becoming part of the political agenda. The potential of science to inform and empower decision making by individuals, communities and society is central to scientific literacy in a democratic society.

Foundation 4: Skills

Foundation 4 is concerned with the skills that students develop in answering questions, solving problems and making decisions. While these skills are not unique to science, they play an important role in the development of scientific understandings and in the application of science and technology to new situations. Four broad skill areas are outlined in the secondary science program. Each skill area is developed at each level with increasing scope and complexity of application.

Initiating and Planning

These are the skills of questioning, identifying problems and developing preliminary ideas and plans.

Performing and Recording

These are the skills of carrying out a plan of action that include gathering evidence by observation and, in most cases, manipulating materials and equipment.

Analyzing and Interpreting

These are the skills of examining information and evidence; of processing and presenting data so that they can be interpreted; and of interpreting, evaluating and applying the results.

Communication and Teamwork

In science, as in other areas, communication skills are essential at every stage during which ideas are being developed, tested, interpreted, debated and agreed upon. Teamwork skills are also important, as the development and application of science ideas are collaborative processes both in society and in the classroom.

PROGRAM ORGANIZATION

Attitude Outcomes

A listing of Attitude outcomes is included at the beginning of each of the 20-level and 30-level courses in the senior high school sciences program. These specific outcomes are to be developed throughout the particular course in conjunction with the specific outcomes for Knowledge, STS and Skills listed within each unit of study.

Units of Study

In the senior high school sciences program, four units of study are outlined for each course. Each unit in the 20-level and 30-level courses includes the following components.

Themes

Themes are the major ideas of science that transcend topics of study.

Overview

The overview introduces the contents of the unit and suggests an approach to unit development.

Links to Mathematics

This section lists topics from mathematics programs of study that are related to the science content of the unit.

Focusing Questions

These questions frame a context for introducing the unit and suggest a focus for investigative activities and application of ideas by students.

Key Concepts

Key concepts identify major ideas to be developed in the unit. Some of the concepts may be addressed in additional units of the same course, as well as in other courses. The intended scope of treatment of these concepts is indicated by the outcomes.

Outcomes

Two levels of outcomes are provided in each unit:

- General Outcomes: These are the major outcomes in the unit that students are to demonstrate over the course of their learning.
- Specific Outcomes: These are detailed outcomes that delineate the scope of each general outcome and the unit. Specific outcomes for Knowledge; Science, Technology and Society (STS); and Skills are identified.

The outcomes are numbered for the purpose of referencing. This numbering is not intended to imply a fixed instructional sequence.

Examples

Many of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

STS Emphases

The specific outcomes for Science, Technology and Society (STS) and Skills for each general outcome in a unit include one of the following emphases:

- Nature of Science
- Science and Technology
- Social and Environmental Contexts

The STS emphases provide opportunities for students to develop related concepts and skills as outlined on pages 8 to 10.

Additional Links

Links to the STS emphasis frameworks (pages 8 to 10) are shown in **boldface** and (in parentheses) after specific outcomes for STS and after specific outcomes or examples for Skills. Links to the Division 4 ICT curriculum (pages 11 to 13) are shown in **boldface** and [in brackets] after some of the specific outcomes and examples for STS and Skills. The STS and ICT links indicate that the concept or skill from the STS emphasis framework or the Division 4 ICT outcome has been addressed in the specific outcome or example.

Note: The listing of STS and ICT links is not exhaustive; other links may exist.

Framework for Developing a Nature of Science Emphasis (Grades 10–12)

The following concepts and skills are developed through this STS emphasis.

Concepts (focus on how scientific knowledge is developed)

Students will develop an understanding that:

- the goal of science is knowledge about the natural world **(NS1)**
- scientific knowledge and theories develop through hypotheses, the collection of evidence, investigation and the ability to provide explanations **(NS2)**
- scientific knowledge results from peer review and replication of the research of others **(NS3)**
- scientific knowledge is subject to change as new evidence becomes apparent and as laws and theories are tested and subsequently revised, reinforced or rejected **(NS4)**
- the process of scientific investigation includes **(NS5)**:
  - identifying the theoretical basis of the investigation **(NS5a)**
  - defining and delimiting, clearly, research questions or ideas to be tested **(NS5b)**
  - designing the investigation **(NS5c)**
  - evaluating and selecting means to collect and record evidence **(NS5d)**
  - carrying out the investigation **(NS5e)**
  - analyzing the evidence and providing explanations based upon scientific theories and concepts **(NS5f)**
- scientific paradigms are conceptual inventions that help organize, interpret and explain findings **(NS6)**
  - Concepts, models and theories are often used in interpreting and explaining observations and in predicting future observations **(NS6a)**
  - Conventions of mathematics, nomenclature and notation provide a basis for organizing and communicating scientific theory, relationships and concepts; e.g., chemical symbols **(NS6b)**
  - Scientific language is precise, and specific terms may be used in each field of study **(NS6c)**
- scientific inquiry is limited to certain questions **(NS7)**

Skills (focus on scientific inquiry)

Initiating and Planning **(IP–NS)**
Students will:
- identify, define and delimit questions to investigate **(IP–NS1)**
- design an experiment, identifying and controlling major variables **(IP–NS2)**
- state a prediction and a hypothesis based on available evidence or background information or on a theory **(IP–NS3)**
- evaluate and select appropriate procedures, including appropriate sampling procedures, and instruments for collecting evidence and information **(IP–NS4)**

Performing and Recording **(PR–NS)**
Students will:
- research, integrate and synthesize information from various print and electronic sources regarding a scientific question **(PR–NS1)**
- select and use appropriate instruments for collecting data effectively, safely and accurately **(PR–NS2)**
- carry out procedures, controlling the major variables, and adapt or extend procedures where required **(PR–NS3)**
- compile and organize findings and data by hand or computer, using appropriate formats such as diagrams, flowcharts, tables and graphs **(PR–NS4)**
- apply Workplace Hazardous Materials Information System (WHMIS) standards to handle and dispose of materials **(PR–NS5)**

Analyzing and Interpreting **(AI–NS)**
Students will:
- apply appropriate terminology, classification systems and nomenclature used in the sciences **(AI–NS1)**
- interpret patterns and trends in data and predict the value of a variable by interpolating or extrapolating from graphical data or from a line of best fit **(AI–NS2)**
- estimate and calculate the value of variables, compare theoretical and empirical values, and account for discrepancies **(AI–NS3)**
- identify limitations of data or measurements; explain sources of error; and evaluate the relevance, reliability and adequacy of data and data collection methods **(AI–NS4)**
- identify new questions or problems that arise from what was learned **(AI–NS5)**
- state a conclusion, based on data obtained from investigations, and explain how evidence gathered supports or refutes a hypothesis, prediction or theory **(AI–NS6)**

Communication and Teamwork **(CT–NS)**
Students will:
- work collaboratively to develop and carry out investigations **(CT–NS1)**
- select and use appropriate numeric, symbolic, graphical and linguistic modes of representation to communicate findings and conclusions **(CT–NS2)**
- evaluate individual and group processes used in planning and carrying out investigative tasks **(CT–NS3)**

Framework for Developing a Science and Technology Emphasis (Grades 10–12)

The following concepts and skills are developed through this STS emphasis.

Concepts (focus on the interrelationship of science and technology)

Students will develop an understanding that:

- the goal of technology is to provide solutions to practical problems **(ST1)**
- technological development may involve the creation of prototypes, the testing of prototypes and the application of knowledge from related scientific and interdisciplinary fields **(ST2)**
- technological problems often require multiple solutions that involve different designs, materials and processes and that have both intended and unintended consequences **(ST3)**
- scientific knowledge may lead to the development of new technologies, and new technologies may lead to or facilitate scientific discovery **(ST4)**
- the process for technological development includes **(ST5)**:
  - defining and delimiting, clearly, the problems to be solved and establishing criteria to assess the technological solution **(ST5a)**
  - identifying the constraints, the benefits and the drawbacks **(ST5b)**
  - developing designs and prototypes **(ST5c)**
  - testing and evaluating designs and prototypes on the basis of established criteria **(ST5d)**
- the products of technology are devices, systems and processes that meet given needs; however, these products cannot solve all problems **(ST6)**
- the appropriateness, risks and benefits of technologies need to be assessed for each potential application from a variety of perspectives, including sustainability **(ST7)**

Skills (focus on problem solving)

Initiating and Planning **(IP–ST)**
Students will:

- identify questions to investigate arising from practical problems **(IP–ST1)**
- propose and assess alternative solutions to a given practical problem, select one and develop a plan **(IP–ST2)**
- evaluate and select appropriate procedures and instruments for collecting data and information and for solving problems **(IP–ST3)**

Performing and Recording **(PR–ST)**
Students will:

- research, integrate and synthesize information from various print and electronic sources relevant to a practical problem **(PR–ST1)**
- construct and test a prototype device or system and troubleshoot problems as they arise **(PR–ST2)**
- select and use tools, apparatus and materials safely **(PR–ST3)**

Analyzing and Interpreting **(AI–ST)**
Students will:

- evaluate designs and prototypes on the basis of self-developed criteria; e.g., function, reliability, cost, safety, efficient use of materials, impact on the environment **(AI–ST1)**
- analyze alternative solutions to a given problem, identify potential strengths and weaknesses of each and recommend an approach to solving the problem, based on findings **(AI–ST2)**
- solve problems by selecting appropriate technology to perform manipulations and calculations **(AI–ST3)**
- identify new questions and problems that arise from what was learned and evaluate potential applications of findings **(AI–ST4)**

Communication and Teamwork **(CT–ST)**
Students will:

- work collaboratively to test a prototype device or system and troubleshoot problems as they arise **(CT–ST1)**
- select and use appropriate numeric, symbolic, graphical and linguistic modes of representation to communicate findings and conclusions **(CT–ST2)**
- evaluate individual and group processes used in planning and carrying out problem-solving tasks **(CT–ST3)**

Framework for Developing a Social and Environmental Contexts Emphasis (Grades 10–12)

The following concepts and skills are developed through this STS emphasis.

Concepts (focus on issues related to the application of science and technology)

Students will develop an understanding that:

- science and technology are developed to meet societal needs and expand human capability **(SEC1)**
- science and technology have influenced, and been influenced by, historical development and societal needs **(SEC2)**
- science and technology have both intended and unintended consequences for humans and the environment **(SEC3)**
- society provides direction for scientific and technological development **(SEC4)**
  - Canadian society supports scientific research and technological development to facilitate a sustainable society, economy and environment **(SEC4a)**
  - Decisions regarding the application of scientific and technological development involve a variety of perspectives, including social, cultural, environmental, ethical and economic considerations **(SEC4b)**
  - Society supports scientific and technological development by recognizing accomplishments, publishing and disseminating results and providing financial support **(SEC4c)**
- scientific and technological activity may arise from, and give rise to, such personal and social values as accuracy, honesty, perseverance, tolerance, open-mindedness, critical-mindedness, creativity and curiosity **(SEC5)**
- science and technology provide opportunities for a diversity of careers based on post-secondary studies, for the pursuit of hobbies and interests, and for lifelong learning **(SEC6)**

Skills (focus on applying science to inform decision-making processes)

Initiating and Planning **(IP–SEC)**
Students will:

- identify questions to investigate that arise from issues related to the application of science and technology **(IP–SEC1)**
- plan complex searches for information, using a wide variety of electronic and print sources **(IP–SEC2)**
- assess and develop appropriate processes for collecting relevant data and information about science-and-technology-related issues **(IP–SEC3)**

Performing and Recording **(PR–SEC)**
Students will:

- research, integrate and synthesize information from various print and electronic sources relevant to a given question, problem or issue **(PR–SEC1)**
- select information and gather evidence from appropriate sources and evaluate search strategies **(PR–SEC2)**

Analyzing and Interpreting **(AI–SEC)**
Students will:

- apply given criteria for evaluating evidence and assess the authority, reliability, scientific accuracy and validity of sources of information **(AI–SEC1)**
- apply a variety of perspectives in assessing the risks and benefits of scientific and technological developments **(AI–SEC2)**
- assess potential decisions and recommend the best one, based on findings **(AI–SEC3)**
- identify new questions that arise and evaluate, from a variety of perspectives, potential implications of findings **(AI–SEC4)**

Communication and Teamwork **(CT–SEC)**
Students will:

- work collaboratively to investigate a science-and-technology-related issue **(CT–SEC1)**
- communicate in a persuasive and an engaging manner, using appropriate multimedia forms, to further understand a complex science-and-technology-related issue **(CT–SEC2)**
- make clear and logical arguments to defend a given decision on an issue, based on findings **(CT–SEC3)**
- evaluate individual and group processes used in investigating an issue and in evaluating alternative decisions **(CT–SEC4)**

Division 4 ICT Outcomes

Category: Communicating, Inquiring, Decision Making and Problem Solving

General Outcomes	Specific Outcomes
C1 **Students will access, use and communicate information from a variety of technologies.**	**C1** 4.1 plan and perform complex searches, using more than one electronic source 4.2 select information from appropriate sources, including primary and secondary sources 4.3 evaluate and explain the advantages and disadvantages of various search strategies 4.4 communicate in a persuasive and engaging manner, through appropriate forms, such as speeches, letters, reports and multimedia presentations, applying information technologies for context, audience and purpose that extend and communicate understanding of complex issues
C2 **Students will seek alternative viewpoints, using information technologies.**	**C2** 4.1 consult a wide variety of sources that reflect varied viewpoints on particular topics 4.2 evaluate the validity of gathered viewpoints against other sources
C3 **Students will critically assess information accessed through the use of a variety of technologies.**	**C3** 4.1 assess the authority, reliability and validity of electronically accessed information 4.2 demonstrate discriminatory selection of electronically accessed information that is relevant to a particular topic
C4 **Students will use organizational processes and tools to manage inquiry.**	**C4** 4.1 use calendars, time management or project management software to assist in conducting an inquiry
C5 **Students will use technology to aid collaboration during inquiry.**	**C5** 4.1 use telecommunications to pose critical questions to experts 4.2 participate in a variety of electronic group formats
C6 **Students will use technology to investigate and/or solve problems.**	**C6** 4.1 investigate and solve problems of prediction, calculation and inference 4.2 investigate and solve problems of organization and manipulation of information 4.3 manipulate data by using charting and graphing technologies in order to test inferences and probabilities 4.4 generate new understandings of problematic situations by using some form of technology to facilitate the process 4.5 evaluate the appropriateness of the technology used to investigate or solve a problem
C7 **Students will use electronic research techniques to construct personal knowledge and meaning.**	**C7** 4.1 use appropriate strategies to locate information to meet personal needs 4.2 analyze and synthesize information to determine patterns and links among ideas 4.3 use appropriate presentation software to demonstrate personal understandings

Division 4 ICT Outcomes (continued)

Category: Foundational Operations, Knowledge and Concepts

General Outcomes	Specific Outcomes
F1 **Students will demonstrate an understanding of the nature of technology.**	**F1** 4.1 assess the strengths and weaknesses of computer simulations in relation to real-world problems 4.2 solve mathematical and scientific problems by selecting appropriate technology to perform calculations and experiments 4.3 apply terminology appropriate to technology in all forms of communication 4.4 demonstrate an understanding of the general concepts of computer programming and the algorithms that enable technological devices to perform operations and solve problems
F2 **Students will understand the role of technology as it applies to self, work and society.**	**F2** 4.1 use technology outside formal classroom settings 4.2 analyze how technological innovations and creativity affect the economy 4.3 demonstrate an understanding of new and emerging communication systems 4.4 evaluate possible potential for emerging technologies 4.5 demonstrate conservation measures when using technology 4.6 demonstrate an understanding of the basic principles and issues of e-commerce, including such topics as security and privacy, marketing, and implications for governments, businesses and consumers alike 4.7 use current, reliable information sources from around the world 4.8 analyze and assess the impact of technology on the global community
F3 **Students will demonstrate a moral and ethical approach to the use of technology.**	**F3** 4.1 demonstrate an understanding of how changes in technology can benefit or harm society 4.2 record relevant data for acknowledging sources of information, and cite sources correctly 4.3 respect ownership and integrity of information
F4 **Students will become discerning consumers of mass media and electronic information.**	**F4** 4.1 discriminate between style and content in a presentation 4.2 evaluate the influence and results of digital manipulation on our perceptions 4.3 identify and analyze a variety of factors that affect the authenticity of information derived from mass media and electronic communication
F5 **Students will practise the concepts of ergonomics and safety when using technology.**	**F5** 4.1 assess new physical environments with respect to ergonomics 4.2 identify safety regulations specific to the technology being used
F6 **Students will demonstrate a basic understanding of the operating skills required in a variety of technologies.**	**F6** 4.1 continue to demonstrate the outcomes addressed within the previous divisions. Students interested in pursuing advanced study in such areas as electronics, programming, computer-aided design and drafting (CADD), robotics and other industrial applications of technology will find opportunities in Career and Technology Studies (CTS) courses

Division 4 ICT Outcomes (continued)

Category: Processes for Productivity

General Outcomes	Specific Outcomes
P1 **Students will compose, revise and edit text.**	**P1** 4.1 continue to demonstrate the outcomes achieved in prior grades and course subjects
P2 **Students will organize and manipulate data.**	**P2** 4.1 manipulate and present data through the selection of appropriate tools, such as scientific instrumentation, calculators, databases and/or spreadsheets
P3 **Students will communicate through multimedia.**	**P3** 4.1 select and use, independently, multimedia capabilities for presentations in various subject areas 4.2 support communication with appropriate images, sounds and music 4.3 apply general principles of graphic layout and design to a document in process
P4 **Students will integrate various applications.**	**P4** 4.1 integrate a variety of visual and audio information into a document to create a message targeted for a specific audience 4.2 apply principles of graphic design to enhance meaning and audience appeal 4.3 use integrated software effectively and efficiently to reproduce work that incorporates data, graphics and text
P5 **Students will navigate and create hyperlinked resources.**	**P5** 4.1 create multiple-link documents appropriate to the content of a particular topic 4.2 post multiple-link pages on the World Wide Web or on a local or wide area network
P6 **Students will use communication technology to interact with others.**	**P6** 4.1 select and use the appropriate technologies to communicate effectively with a targeted audience

CHEMISTRY 20

Chemistry 20 consists of four units of study:

A. The Diversity of Matter and Chemical Bonding
B. Forms of Matter: Gases
C. Matter as Solutions, Acids and Bases
D. Quantitative Relationships in Chemical Changes

Attitude Outcomes

Students will be encouraged to develop positive attitudes that support the responsible acquisition and application of knowledge related to science and technology. The following attitude outcomes are to be developed throughout Chemistry 20, in conjunction with the specific outcomes for Knowledge; Science, Technology and Society (STS); and Skills in each unit.

Interest in Science

Students will be encouraged to:
show interest in science-related questions and issues and confidently pursue personal interests and career possibilities within science-related fields; *e.g.,*

- *appreciate how scientific problem solving and new technologies are related*
- *appreciate the usefulness of models and theories in helping explain the structure and behaviour of matter*
- *investigate careers in fields such as food science, engineering, laboratory technology, environmental chemistry, agriculture, water treatment and forensic science*
- *develop an interest in the role of chemistry in daily life*
- *develop a questioning attitude and a desire to understand more about matter*
- *express interest in science and technology topics not directly related to their formal studies*
- *develop an awareness of the relationship between chemical principles and applications of chemistry*
- *identify industrial, commercial and household processes and products and associated careers that require a knowledge of quantitative analysis.*

Mutual Respect

Students will be encouraged to:
appreciate that scientific understanding evolves from the interaction of ideas involving people with different views and backgrounds; *e.g.,*

- *use a multiperspective approach, considering scientific, technological, economic, cultural, political and environmental factors when formulating conclusions, solving problems or making decisions on an STS issue*
- *recognize that theories develop as a result of the sharing of ideas by many scientists*
- *trace, from a historical perspective, how the observations and experimental work of many individuals led to modern understandings of matter*
- *value traditional knowledge of common solutions and substances*
- *research the role of chemistry in the International Space Station project*
- *investigate how early peoples developed recipes for common foods, cleaners and remedies*
- *recognize that the scientific approach is one of many ways of viewing the universe*
- *recognize the contributions of various peoples and cultures in advancing understanding and applications of chemistry*
- *recognize the research contributions of both men and women*
- *recognize the research contributions of Canadians.*

Scientific Inquiry

Students will be encouraged to:
seek and apply evidence when evaluating alternative approaches to investigations, problems and issues; *e.g.,*

- *develop curiosity about the nature of chemistry*
- *tolerate the uncertainty involved in providing explanations and theoretical definitions*
- *appreciate the limited nature of evidence when interpreting observed phenomena*
- *appreciate that scientific evidence is the foundation for generalizations and explanations about chemistry*
- *value the role of precise observation and careful experimentation in learning about chemistry.*

Collaboration

Students will be encouraged to:
work collaboratively in planning and carrying out investigations and in generating and evaluating ideas; *e.g.,*

- *assume a variety of roles within a group, as required*
- *accept responsibility for any task that helps the group complete an activity*
- *evaluate the ideas of others objectively*
- *seek the points of view of others and consider a multitude of perspectives.*

Stewardship

Students will be encouraged to:
demonstrate sensitivity and responsibility in pursuing a balance between the needs of humans and a sustainable environment; *e.g.,*

- *evaluate, willingly, the impact of their own choices or the choices scientists make when they carry out an investigation*
- *remain critical-minded regarding the short- and long-term consequences of human actions*
- *consider a variety of perspectives when addressing issues, weighing scientific, technological, economic, political and ecological factors*
- *develop an awareness that the application of technology has risks and benefits*
- *evaluate the contributions of technological innovations to quality of life and care of the environment.*

Safety

Students will be encouraged to:
show concern for safety in planning, carrying out and reviewing activities, referring to the Workplace Hazardous Materials Information System (WHMIS) and consumer product labelling information; *e.g.,*

- *treat equipment with respect and manipulate materials carefully*
- *value the need for safe handling and storage of chemicals*
- *recognize the significant role that chemical researchers and the chemical industry play in identifying risks and developing guidelines for safe exposure*
- *use minimal quantities of chemicals when performing experiments*
- *keep the work station uncluttered, with only appropriate laboratory materials present*
- *assume responsibility for the safety of all those who share a common working environment*
- *clean up after an activity and dispose of materials in a safe place according to safety guidelines.*

Unit A: The Diversity of Matter and Chemical Bonding

Themes: Diversity and Matter

Overview: Concepts, models and theories are often used in interpreting and explaining observations and in predicting future observations. The major focus of this unit is to relate theories about bonding to the properties of matter and to develop explanations and descriptions of structure and bonding through scientific models. Students learn about the diversity of matter through the investigation of ionic compounds and molecular substances.

This unit builds on:
- Grade 9 Science, Unit B: Matter and Chemical Change
- Science 10, Unit A: Energy and Matter in Chemical Change

This unit provides a background for:
- Chemistry 30, Unit A: Thermochemical Changes, Unit B: Electrochemical Changes and Unit C: Chemical Changes of Organic Compounds

Unit A will require approximately 20% of the time allotted for Chemistry 20.

Links to Mathematics: The following mathematics topics are related to the content of Unit A but are not considered prerequisites.

Topics:	These topics may be found in the following courses:
• graphing and interpreting data	Pure Mathematics 10, specific outcome 3.1
• linear equations	Pure Mathematics 10, specific outcome 2.7; Applied Mathematics 10, specific outcomes 1.2, 1.3 and 5.1
• measurement	Applied Mathematics 20, specific outcomes 6.2, 6.3 and 6.4

Focusing Questions: Why do some substances dissolve easily, whereas others do not? Why do different substances have different melting and boiling points and enthalpies of fusion and vaporization? How can models increase understanding of bonding?

General Outcomes: There are two major outcomes in this unit.

Students will:

1. describe the role of modelling, evidence and theory in explaining and understanding the structure, chemical bonding and properties of ionic compounds
2. describe the role of modelling, evidence and theory in explaining and understanding the structure, chemical bonding and properties of molecular substances.

Key Concepts: The following concepts are developed in this unit and may also be addressed in other units or in other courses. The intended level and scope of treatment is defined by the outcomes.

- chemical bond
- ionic bond
- covalent bond
- electronegativity
- polarity
- valence electron
- intramolecular and intermolecular forces
- hydrogen bond
- electron dot diagrams
- Lewis structures
- valence-shell electron-pair repulsion (VSEPR) theory

General Outcome 1
Students will describe the role of modelling, evidence and theory in explaining and understanding the structure, chemical bonding and properties of ionic compounds.

Specific Outcomes for Knowledge

Students will:

20–A1.1k recall principles for assigning names to ionic compounds

20–A1.2k explain why formulas for ionic compounds refer to the simplest whole-number ratio of ions that result in a net charge of zero

20–A1.3k define valence electron, electronegativity, ionic bond and intramolecular force

20–A1.4k use the periodic table and electron dot diagrams to support and explain ionic bonding theory

20–A1.5k explain how an ionic bond results from the simultaneous attraction of oppositely charged ions

20–A1.6k explain that ionic compounds form lattices and that these structures relate to the compounds' properties; *e.g., melting point, solubility, reactivity*.

Specific Outcomes for Science, Technology and Society (STS) (Nature of Science Emphasis)

Students will:

20–A1.1sts explain that the goal of science is knowledge about the natural world **(NS1)**
- *identify everyday processes and products in which ionic compounds are significant, such as in the composition of household products and foods and in life processes*

20–A1.2sts explain that scientific knowledge and theories develop through hypotheses, the collection of evidence, investigation and the ability to provide explanations **(NS2)**
- *describe how an understanding of electronegativity contributes to knowledge of relative bond strength, melting points and boiling points of ionic compounds*

20–A1.3sts explain that scientific knowledge may lead to the development of new technologies, and new technologies may lead to or facilitate scientific discovery **(ST4) [ICT F2–4.4, F2–4.8]**
- *explain how scientific research and technology interact in the production and distribution of beneficial materials, such as semiconductors, ceramics and composite materials.*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 1
Students will describe the role of modelling, evidence and theory in explaining and understanding the structure, chemical bonding and properties of ionic compounds.

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

Students will:

20–A1.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- design an investigation to determine the properties of ionic compounds (solubility, conductivity and melting point) **(IP–NS2)**
- describe procedures for the safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information **(IP–NS4)**
- *research the question, "Should all scientific research have a practical application?"* **(IP–NS1) [ICT C2–4.1]**
- *design an experiment to explore the formation of ionic compounds* **(IP–NS2)**.

Performing and Recording

Students will:

20–A1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- draw electron dot diagrams **(CT–NS2)**
- *build models of ionic solids* **(CT–NS2)**
- *perform an investigation to illustrate properties of ionic compounds* **(PR–NS3, PR–NS5)**
- *use the periodic table to make predictions about bonding and nomenclature* **(PR–NS1, AI–NS1)**
- *use model-building software to collect and integrate information on the structure of ionic crystals* **(PR–NS4) [ICT C6–4.4]**.

Analyzing and Interpreting

Students will:

20–A1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- analyze experimental data to determine the properties of ionic compounds **(AI–NS6) [ICT C7–4.2]**
- *use data from various sources to predict the strength of bonds between ions* **(PR–NS1, AI–NS2) [ICT C6–4.1]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 1
Students will describe the role of modelling, evidence and theory in explaining and understanding the structure, chemical bonding and properties of ionic compounds.

Communication and Teamwork

Students will:

20–A1.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- use appropriate International System of Units (SI) notation, fundamental and derived units and significant digits **(CT–NS2)**★
- use appropriate numeric, symbolic, graphical and linguistic modes of representation to communicate ideas, plans and results **(CT–NS2)**★
- *analyze, critically, models of ionic compounds built by others* **(CT–NS3)**.

★ To be developed throughout the course.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will describe the role of modelling, evidence and theory in explaining and understanding the structure, chemical bonding and properties of molecular substances.

Specific Outcomes for Knowledge

Students will:

20–A2.1k recall principles for assigning names to molecular substances

20–A2.2k explain why formulas for molecular substances refer to the number of atoms of each constituent element

20–A2.3k relate electron pairing to multiple and covalent bonds

20–A2.4k draw electron dot diagrams of atoms and molecules, writing structural formulas for molecular substances and using Lewis structures to predict bonding in simple molecules

20–A2.5k apply VSEPR theory to predict molecular shapes for linear, angular (V-shaped, bent), tetrahedral, trigonal pyramidal and trigonal planar molecules

20–A2.6k illustrate, by drawing or by building models, the structure of simple molecular substances

20–A2.7k explain intermolecular forces, London (dispersion) forces, dipole-dipole forces and hydrogen bonding

20–A2.8k relate properties of substances (*e.g., melting and boiling points, enthalpies of fusion and vaporization*) to the predicted intermolecular bonding in the substances

20–A2.9k determine the polarity of a molecule based on simple structural shapes and unequal charge distribution

20–A2.10k describe bonding as a continuum ranging from complete electron transfer to equal sharing of electrons.

Specific Outcomes for Science, Technology and Society (STS) (Nature of Science Emphasis)

Students will:

20–A2.1sts explain that the goal of science is knowledge about the natural world **(NS1)**
- *identify everyday processes and products in which molecular substances are significant, such as in the composition of household products and foods and in life processes*
- *identify examples of processes and products in which molecular substances are significant, such as in the use of adhesives and rubber by Aboriginal peoples*

20–A2.2sts explain that scientific knowledge and theories develop through hypotheses, the collection of evidence, investigation and the ability to provide explanations **(NS2)**
- *relate chemical properties to predicted intermolecular bonding by investigating melting and boiling points*

20–A2.3sts explain that scientific knowledge is subject to change as new evidence becomes apparent and as laws and theories are tested and subsequently revised, reinforced or rejected **(NS4)**
- *explain how scientific research and technology interact in the production and distribution of beneficial materials, such as polymers, household products and solvents*
- *investigate how basic knowledge about the structure of matter is advanced through nanotechnology research and development.*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will describe the role of modelling, evidence and theory in explaining and understanding the structure, chemical bonding and properties of molecular substances.

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

Students will:

20–A2.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- state a hypothesis and make a prediction about the properties of molecular substances based on attractive forces; *e.g., melting or boiling point, enthalpies of fusion and vaporization* **(IP–NS3)**
- describe procedures for the safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information **(IP–NS4)**.

Performing and Recording

Students will:

20–A2.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- build models depicting the structure of simple covalent molecules, including selected organic compounds **(CT–NS2)**
- carry out an investigation to determine the melting or boiling point of a molecular substance **(PR–NS3, PR–NS5)**
- *use a thermometer and a conductivity apparatus to collect data* **(PR–NS2)**
- *carry out an investigation to compare the physical properties of molecular substances* **(PR–NS3) [ICT F1–4.2]**.

Analyzing and Interpreting

Students will:

20–A2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- graph and analyze data, for trends and patterns, on the melting and boiling points of a related series of molecular substances **(AI–NS2) [ICT C7–4.2]**.

Communication and Teamwork

Students will:

20–A2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- analyze and evaluate, objectively, models and graphs constructed by others **(CT–NS3)**
- *research the ways that scientists develop and analyze new materials* **(PR–NS1) [ICT C2–4.1]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

Unit B: Forms of Matter: Gases

Themes: Matter, Change and Energy

Overview: Students expand their knowledge of the nature of matter through the investigation of the properties and behaviour of gases.

This unit builds on:
- Grade 9 Science, Unit B: Matter and Chemical Change
- Science 10, Unit A: Energy and Matter in Chemical Change

This unit provides a background for:
- Chemistry 30, Unit D: Chemical Equilibrium Focusing on Acid-Base Systems

Unit B will require approximately 16% of the time allotted for Chemistry 20.

Links to Mathematics: The following mathematics topics are related to the content of Unit B but are not considered prerequisites.

Topics:	These topics may be found in the following courses:
• linear equations	Pure Mathematics 10, specific outcome 2.7; Applied Mathematics 10, specific outcomes 1.2, 1.3 and 5.1
• nonlinear equations	Pure Mathematics 10, specific outcomes 3.1 and 4.2; Pure Mathematics 20, specific outcomes 3.1 and 6.4; Applied Mathematics 10, specific outcomes 3.1, 3.2 and 3.3; Applied Mathematics 20, specific outcomes 2.1, 2.3, 2.4 and 2.5
• measurement	Applied Mathematics 20, specific outcomes 6.2, 6.3 and 6.4

Focusing Questions: How do familiar observations of gases relate to specific scientific models describing the behaviour of gases? What is the relationship among the pressure, temperature, volume and amount of a gas? How is the behaviour of gases used in various technologies?

General Outcomes: There is one major outcome in this unit.

Students will:

1. explain molecular behaviour, using models of the gaseous state of matter.

Key Concepts: The following concepts are developed in this unit and may also be addressed in other units or in other courses. The intended level and scope of treatment is defined by the outcomes.
- Celsius and Kelvin temperature scales
- absolute zero
- real and ideal gases
- law of combining volumes
- Charles's law
- Boyle's law
- ideal gas law
- standard temperature and pressure (STP)
- standard ambient temperature and pressure (SATP)

General Outcome 1
Students will explain molecular behaviour, using models of the gaseous state of matter.

Specific Outcomes for Knowledge

Students will:

20–B1.1k describe and compare the behaviour of real and ideal gases in terms of kinetic molecular theory

20–B1.2k convert between the Celsius and Kelvin temperature scales

20–B1.3k explain the law of combining volumes

20–B1.4k illustrate how Boyle's and Charles's laws, individually and combined, are related to the ideal gas law ($PV = nRT$)

- express pressure in a variety of ways, including units of kilopascals, atmospheres and millimetres of mercury
- perform calculations, based on the gas laws, under STP, SATP and other defined conditions.

Specific Outcomes for Science, Technology and Society (STS) (Nature of Science Emphasis)

Students will:

20–B1.1sts explain that science provides a conceptual and theoretical basis for predicting, interpreting and explaining natural and technological phenomena **(NS5)**

- *describe how the development of technologies capable of precise measurements of temperature and pressure (such as thermocouples, thermistors and Bourdon gauges) led to a better understanding of gases and to the formulation of the gas laws*

20–B1.2sts explain that the goal of science is knowledge about the natural world **(NS1)**

- *describe examples of natural phenomena and processes and products (such as breathing, diffusion, weather, hot air balloons, scuba diving equipment, automobile air bags, gas turbines and internal combustion engines) that illustrate the properties of gases.*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 1
Students will explain molecular behaviour, using models of the gaseous state of matter.

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

Students will:

20–B1.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- state hypotheses and make predictions based on information about the pressure, temperature and volume of a gas **(IP–NS3)**
- describe procedures for the safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information **(IP–NS4)**
- *design an experiment to illustrate Boyle's and/or Charles's gas laws* **(IP–NS2)**
- *design an investigation to determine the universal gas constant (R) or absolute zero* **(IP–NS2)**
- *explore how people who are connected with the land, such as Aboriginal peoples and agricultural workers, have used plant and animal responses to changes in atmospheric pressure as indicators of changing weather* **(IP–NS1)**.

Performing and Recording

Students will:

20–B1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- perform an experiment, in which variables are identified and controlled, to illustrate gas laws **(PR–NS3, PR–NS5) [ICT C6–4.2, F1–4.2]**
- *use thermometers, balances and other measuring devices effectively to collect data on gases* **(PR–NS3) [ICT F1–4.2]**
- *use library and electronic research tools to collect information on real and ideal gases and on applications of gases, such as hot air and weather balloons* **(PR–NS1) [ICT C1–4.1, C1–4.2]**
- *perform an investigation to determine molar mass from gaseous volume* **(PR–NS3, AI–NS6) [ICT C6–4.2]**.

Analyzing and Interpreting

Students will:

20–B1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- graph and analyze experimental data that relate pressure and temperature to gas volume **(AI–NS2)**
- *identify the limitations of measurement* **(AI–NS4)**
- *identify a gas based on an analysis of experimental data* **(AI–NS2) [ICT C7–4.2]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 1
Students will explain molecular behaviour, using models of the gaseous state of matter.

Communication and Teamwork

Students will:

20–B1.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- communicate questions, ideas and intentions and receive, interpret, understand, support and respond to the ideas of others while collecting data on gases **(CT–NS1)**
- *prepare a group presentation, using multimedia, to illustrate how the pressure, temperature, volume and amount of a gas determines the universal gas constant (R)* **(CT–NS2) [ICT P3–4.1]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

Unit C: Matter as Solutions, Acids and Bases

Themes: Matter, Diversity, Systems and Change

Overview: Students gain insight into the nature of matter through an investigation of change in the context of solutions, acids and bases.

This unit builds on:
- Grade 8 Science, Unit A: Mix and Flow of Matter
- Grade 9 Science, Unit B: Matter and Chemical Change and Unit C: Environmental Chemistry
- Science 10, Unit A: Energy and Matter in Chemical Change

This unit provides a background for:
- Chemistry 20, Unit D: Quantitative Relationships in Chemical Changes
- Chemistry 30, Unit B: Electrochemical Changes and Unit D: Chemical Equilibrium Focusing on Acid-Base Systems

Unit C will require approximately 32% of the time allotted for Chemistry 20.

Links to Mathematics: The following mathematics topics are related to the content of Unit C but are not considered prerequisites.

Topics:	These topics may be found in the following courses:
• linear equations	Pure Mathematics 10, specific outcome 2.7; Applied Mathematics 10, specific outcomes 1.2, 1.3 and 5.1
• nonlinear equations	Pure Mathematics 10, specific outcomes 3.1 and 4.2; Pure Mathematics 20, specific outcomes 3.1 and 6.4; Applied Mathematics 10, specific outcomes 3.1, 3.2 and 3.3; Applied Mathematics 20, specific outcomes 2.1, 2.3, 2.4 and 2.5
• measurement	Applied Mathematics 20, specific outcomes 6.2, 6.3 and 6.4

Focusing Questions: How is matter as solutions, acids and bases differentiated on the basis of theories, properties and scientific evidence? Why is an understanding of acid-base and solution chemistry important in our daily lives and in the environment?

General Outcomes: There are two major outcomes in this unit.

Students will:

1. investigate solutions, describing their physical and chemical properties
2. describe acidic and basic solutions qualitatively and quantitatively.

Key Concepts: The following concepts are developed in this unit and may also be addressed in other units or in other courses. The intended level and scope of treatment is defined by the outcomes.

- homogeneous mixtures
- solubility
- electrolyte/nonelectrolyte
- concentration
- dilution
- strong acids and bases
- weak acids and bases
- monoprotic/polyprotic acid
- monoprotic/polyprotic base
- Arrhenius (modified) theory of acids and bases
- indicators
- hydronium ion/pH
- hydroxide ion/pOH
- neutralization

General Outcome 1
Students will investigate solutions, describing their physical and chemical properties.

Specific Outcomes for Knowledge

Students will:

20–C1.1k recall the categories of pure substances and mixtures and explain the nature of homogeneous mixtures
20–C1.2k provide examples from living and nonliving systems that illustrate how dissolving substances in water is often a prerequisite for chemical change
20–C1.3k explain dissolving as an endothermic or exothermic process with respect to the breaking and forming of bonds
20–C1.4k differentiate between electrolytes and nonelectrolytes
20–C1.5k express concentration in various ways; i.e., moles per litre of solution, percent by mass and parts per million
20–C1.6k calculate, from empirical data, the concentration of solutions in moles per litre of solution and determine mass or volume from such concentrations
20–C1.7k calculate the concentrations and/or volumes of diluted solutions and the quantities of a solution and water to use when diluting
20–C1.8k use data and ionization/dissociation equations to calculate the concentration of ions in a solution
20–C1.9k define solubility and identify related factors; i.e., temperature, pressure and miscibility
20–C1.10k explain a saturated solution in terms of equilibrium; i.e., equal rates of dissolving and crystallization
20–C1.11k describe the procedures and calculations required for preparing and diluting solutions.

Specific Outcomes for Science, Technology and Society (STS) (Social and Environmental Contexts Emphasis)

Students will:

20–C1.1sts explain how science and technology are developed to meet societal needs and expand human capability **(SEC1) [ICT F2–4.8]**
- *provide examples of how solutions and solution concentrations are applied in products and processes, scientific studies and daily life*

20–C1.2sts explain that science and technology have influenced, and been influenced by, historical development and societal needs **(SEC2) [ICT F2–4.8]**
- *compare the ways in which concentrations of solutions are expressed in chemistry laboratories, household products and environmental studies*

20–C1.3sts explain that scientific and technological activity may arise from, and give rise to, such personal and social values as accuracy, honesty, perseverance, tolerance, open-mindedness, critical-mindedness, creativity and curiosity **(SEC5)**
- *explain the Responsible Care program developed by the Canadian Chemical Producers' Association*

20–C1.4sts explain how science and technology have both intended and unintended consequences for humans and the environment **(SEC3) [ICT F3–4.1]**
- *explain the significance of biomagnification in increasing the concentration of substances in an ecosystem*

20–C1.5sts explain that the appropriateness, risks and benefits of technologies need to be assessed for each potential application from a variety of perspectives, including sustainability **(ST7) [ICT F2–4.2, F3–4.1]**
- *explain the role of concentration in risk-benefit analyses for determining the safe limits of particular substances, such as pesticide residues, heavy metals, chlorinated or fluorinated compounds and pharmaceuticals.*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 1
Students will investigate solutions, describing their physical and chemical properties.

Specific Outcomes for Skills (Social and Environmental Contexts Emphasis)

Initiating and Planning

Students will:

20–C1.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- design a procedure to identify the type of solution **(IP–NS2)**
- design a procedure to determine the concentration of a solution containing a solid solute **(IP–NS2)**
- describe procedures for the safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information **(IP–SEC3, PR–NS5)**.

Performing and Recording

Students will:

20–C1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- use a conductivity apparatus to differentiate solutions **(PR–NS2) [ICT C6–4.4]**
- perform an experiment to determine the concentration of a solution **(PR–NS3, PR–NS5)**
- use a balance and volumetric glassware to prepare solutions of specified concentrations **(PR–NS2, PR–NS5)**
- perform an investigation to determine the solubility of a solute in a saturated solution **(PR–ST3, PR–NS5) [ICT C6–4.2]**.

Analyzing and Interpreting

Students will:

20–C1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- use experimental data to determine the concentration of a solution **(AI–NS3) [ICT C6–4.1]**
- *evaluate the risks involved in the handling, storage and disposal of solutions commonly used in the laboratory and in the home* **(AI–SEC2, PR–NS5)**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 1
Students will investigate solutions, describing their physical and chemical properties.

Communication and Teamwork

Students will:

20–C1.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- compare personal concentration data with the data collected by other individuals or groups **(CT–SEC4)**
- select and use appropriate numeric, symbolic, graphical and linguistic modes of representation to communicate ideas, plans and results **(CT–NS2)**
- *use integrated software effectively and efficiently to incorporate data, graphics and text* **(CT–ST2) [ICT P4–4.3]**
- *conduct, collectively, a risk-benefit analysis of the pollution of waterways by the release of effluents and propose a plan for reducing the impact on the ecosystem* **(IP–SEC3, AI–SEC3, CT–SEC1) [ICT F3–4.1]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will describe acidic and basic solutions qualitatively and quantitatively.

Specific Outcomes for Knowledge

Students will:

20–C2.1k recall International Union of Pure and Applied Chemistry (IUPAC) nomenclature of acids and bases

20–C2.2k recall the empirical definitions of acidic, basic and neutral solutions determined by using indicators, pH and electrical conductivity

20–C2.3k calculate $H_3O^+(aq)$ and $OH^-(aq)$ concentrations and the pH and pOH of acidic and basic solutions based on logarithmic expressions; i.e., $pH = –log[H_3O^+]$ and $pOH = –log[OH^-]$

20–C2.4k use appropriate SI units to communicate the concentration of solutions and express pH and concentration answers to the correct number of significant digits; i.e., use the number of decimal places in the pH to determine the number of significant digits of the concentration

20–C2.5k compare magnitude changes in pH and pOH with changes in concentration for acids and bases

20–C2.6k explain how the use of indicators, pH paper or pH meters can be used to measure $H_3O^+(aq)$

20–C2.7k define Arrhenius (modified) acids as substances that produce $H_3O^+(aq)$ in aqueous solutions and recognize that the definition is limited

20–C2.8k define Arrhenius (modified) bases as substances that produce $OH^-(aq)$ in aqueous solutions and recognize that the definition is limited

20–C2.9k define neutralization as a reaction between hydronium and hydroxide ions

20–C2.10k differentiate, qualitatively, between strong and weak acids and between strong and weak bases on the basis of ionization and dissociation; i.e., pH, reaction rate and electrical conductivity

20–C2.11k identify monoprotic and polyprotic acids and bases and compare their ionization/dissociation.

Specific Outcomes for Science, Technology and Society (STS) (Science and Technology Emphasis)

Students will:

20–C2.1sts explain that the goal of technology is to provide solutions to practical problems **(ST1) [ICT F2–4.4]**

- *relate the concept of pH to solutions encountered in everyday life, such as pharmaceuticals, shampoo and other cleaning products, aquatic and terrestrial environments, and blood/blood products*

20–C2.2sts explain that technological problems often require multiple solutions that involve different designs, materials and processes and that have both intended and unintended consequences **(ST3) [ICT F3–4.1]**

- *provide examples of processes and products that use knowledge of acid and base chemistry (the pulp and paper industry, the petrochemical industry, food preparation and preservation, cleaning aids, sulfuric acid in car batteries, treating accidental acid or base spills using neutralization and dilution)*
- *explain the significance of the strength and concentration of solutions in everyday life (pharmaceuticals, chemical spills, transportation of dangerous goods, toxicity)*
- *identify examples in Alberta in which holistic practices used by some Aboriginal communities can be used to moderate the impact of development in industries such as the petrochemical industry.*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will describe acidic and basic solutions qualitatively and quantitatively.

Specific Outcomes for Skills (Science and Technology Emphasis)

Initiating and Planning

Students will:

20–C2.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- design an experiment to differentiate among acidic, basic and neutral solutions **(IP–NS2)**
- design an experiment to differentiate between weak and strong acids and between weak and strong bases **(IP–NS2)**
- describe procedures for the safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information **(IP–ST3)**.

Performing and Recording

Students will:

20–C2.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- construct a table or graph to compare pH and hydronium ion concentration, illustrating that as the hydronium ion concentration increases, the pH decreases **(PR–NS4)**
- *use a pH meter to determine the acidity and/or alkalinity of a solution* **(PR–NS2) [ICT C6–4.4]**.

Analyzing and Interpreting

Students will:

20–C2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- use indicators to determine the pH for a variety of solutions **(PR–NS2, AI–NS6)**
- *assess, qualitatively, the risks and benefits of producing, using and transporting acidic and basic substances, based on WHMIS and transportation of dangerous goods guidelines* **(AI–ST2)**.

Communication and Teamwork

Students will:

20–C2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- *research, collectively, the relationship between sulfuric acid and industrialization* **(CT–SEC1) [ICT C1–4.1, C2–4.1]**
- *evaluate technologies used to reduce emissions that lead to acid deposition* **(CT–SEC1) [ICT C6–4.5]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

Unit D: Quantitative Relationships in Chemical Changes

Themes: Matter and Change

Overview: Students focus on chemical change and the quantitative relationships contained in balanced chemical equations. They are required to use stoichiometric principles and mathematical manipulation to predict quantities of substances consumed or produced in chemical reaction systems.

This unit builds on:

- Science 10, Unit A: Energy and Matter in Chemical Change

This unit provides a background for:

- Chemistry 30, Unit A: Thermochemical Changes, Unit B: Electrochemical Changes and Unit D: Chemical Equilibrium Focusing on Acid-Base Systems

Unit D will require approximately 32% of the time allotted for Chemistry 20.

Links to Mathematics: The following mathematics topics are related to the content of Unit D but are not considered prerequisites.

Topics:	These topics may be found in the following courses:
• linear equations	Pure Mathematics 10, specific outcome 2.7; Applied Mathematics 10, specific outcomes 1.2, 1.3 and 5.1
• measurement	Applied Mathematics 20, specific outcomes 6.2, 6.3 and 6.4

Focusing Questions: How do scientists, engineers and technologists use mathematics to analyze chemical change? How are balanced chemical equations used to predict yields in chemical reactions?

General Outcomes: There are two major outcomes in this unit.

Students will:

1. explain how balanced chemical equations indicate the quantitative relationships between reactants and products involved in chemical changes
2. use stoichiometry in quantitative analysis.

Key Concepts: The following concepts are developed in this unit and may also be addressed in other units or in other courses. The intended level and scope of treatment is defined by the outcomes.

- chemical reaction equations
- net ionic equations
- spectator ions
- reaction stoichiometry
- precipitation
- limiting and excess reagents
- actual, theoretical and percent yield
- titration
- end point
- equivalence point
- titration curves for strong acids and bases

General Outcome 1
Students will explain how balanced chemical equations indicate the quantitative relationships between reactants and products involved in chemical changes.

Specific Outcomes for Knowledge

Students will:

20–D1.1k predict the product(s) of a chemical reaction based upon the reaction type
20–D1.2k recall the balancing of chemical equations in terms of atoms, molecules and moles
20–D1.3k contrast quantitative and qualitative analysis
20–D1.4k write balanced ionic and net ionic equations, including identification of spectator ions, for reactions taking place in aqueous solutions
20–D1.5k calculate the quantities of reactants and/or products involved in chemical reactions, using gravimetric, solution or gas stoichiometry.

Specific Outcomes for Science, Technology and Society (STS) (Science and Technology Emphasis)

Students will:

20–D1.1sts explain that the products of technology are devices, systems and processes that meet given needs; however, these products cannot solve all problems **(ST6) [ICT F2–4.4]**

- *analyze the chemical reactions involved in various industrial and commercial processes and products that use stoichiometric and chemical principles:*
  - *production of urea*
  - *fertilizers*
  - *fuel combustion*
  - *water treatment*
  - *air bag deployment*
  - *neutralization of excess stomach acid.*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 1
Students will explain how balanced chemical equations indicate the quantitative relationships between reactants and products involved in chemical changes.

Specific Outcomes for Skills (Science and Technology Emphasis)

Initiating and Planning

Students will:

20–D1.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- plan and predict states, products and theoretical yields for chemical reactions **(IP–NS3) [ICT C6–4.1]**
- design an experiment to identify an ion; *e.g., precipitation, flame test* **(IP–NS2)**
- describe procedures for the safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information **(IP–ST3)**.

Performing and Recording

Students will:

20–D1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- translate word equations for chemical reactions into chemical equations, including states of matter for the products and reactants **(CT–ST2)**
- balance chemical equations for chemical reactions, using lowest whole-number coefficients **(AI–ST3)**.

Analyzing and Interpreting

Students will:

20–D1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- interpret stoichiometric ratios from chemical reaction equations **(AI–ST3)**
- perform calculations to determine theoretical yields **(AI–NS3) [ICT C6–4.1]**
- use appropriate SI notation, fundamental and derived units and significant digits when performing stoichiometric calculations **(AI–NS3, CT–ST2)**.

Communication and Teamwork

Students will:

20–D1.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- *use integrated software effectively and efficiently to incorporate data and text* **(AI–NS3, CT–ST2) [ICT P4–4.3]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will use stoichiometry in quantitative analysis.

Specific Outcomes for Knowledge

Students will:

20–D2.1k explain chemical principles (i.e., conservation of mass in a chemical change), using quantitative analysis

20–D2.2k identify limiting and excess reagents in chemical reactions

20–D2.3k define theoretical yields and actual yields

20–D2.4k explain the discrepancy between theoretical and actual yields

20–D2.5k draw and interpret titration curves, using data from titration experiments involving strong monoprotic acids and strong monoprotic bases

20–D2.6k describe the function and choice of indicators in titrations

20–D2.7k identify equivalence points on strong monoprotic acid–strong monoprotic base titration curves and differentiate between the indicator end point and the equivalence point.

Specific Outcomes for Science, Technology and Society (STS) (Science and Technology Emphasis)

Students will:

20–D2.1sts explain that scientific knowledge may lead to the development of new technologies, and new technologies may lead to or facilitate scientific discovery **(ST4) [ICT F2–4.4]**

- *describe how industries apply principles of stoichiometry to minimize waste and maximize yield*

20–D2.2sts explain how the appropriateness, risks and benefits of technologies need to be assessed for each potential application from a variety of perspectives, including sustainability **(ST7) [ICT F3–4.1]**

- *assess the significance of specific by-products from industrial, commercial and household chemical reactions*
- *analyze the use of technologies, such as smokestacks and catalytic converters, to reduce emissions that are harmful to the environment, such as $SO_2(g)$ and greenhouse gases.*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will use stoichiometry in quantitative analysis.

Specific Outcomes for Skills (Science and Technology Emphasis)

Initiating and Planning

Students will:

20–D2.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- design a procedure, using crystallization, filtration or titration, to determine the concentration of a solution **(IP–ST2)**
- describe procedures for the safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information **(IP–ST3)**
- predict the approximate equivalence point for a strong monoprotic acid–strong monoprotic base titration and select an appropriate indicator **(IP–NS3, IP–NS4)**.

Performing and Recording

Students will:

20–D2.2s conduct investigations into relationships between and among observable variables and use a broad range of tools and techniques to gather and record data and information

- perform a titration to determine the concentration of an acid or a base restricted to strong monoprotic acid–strong monoprotic base combinations **(PR–NS3)**
- *use probes and software to collect titration data* **(PR–NS2) [ICT C6–4.4]**
- *research methods used by industry to reduce emissions* **(PR–ST1) [ICT F2–4.4]**
- *design a prototype of a chemical industrial plant* **(PR–ST2)**.

Analyzing and Interpreting

Students will:

20–D2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- calculate theoretical and actual yield and percent yield and error, and account for discrepancies between the theoretical and actual yields **(AI–NS3, AI–NS4) [ICT C6–4.1]**
- analyze and evaluate experimental data of a precipitation reaction to determine the concentration of a solution **(AI–NS3, AI–NS4, AI–NS6) [ICT C7–4.2]**
- graph and analyze titration curves for acid-base experiments restricted to strong monoprotic acid–strong monoprotic base combinations **(PR–NS4)**
- use appropriate SI notation, fundamental and derived units and significant digits when performing stoichiometric calculations **(CT–ST2)**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will use stoichiometry in quantitative analysis.

Communication and Teamwork

Students will:

20–D2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- standardize an acidic or a basic solution and compare group results **(PR–NS2)**
- *draw a flowchart for an industrial chemical process* **(CT–ST2)**
- *use integrated software effectively and efficiently to produce work that incorporates data, graphics and text* **(CT–ST2) [ICT P4–4.3]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

CHEMISTRY 30

Implementation of Chemistry 30 is mandatory in September 2008. Implementation prior to this date is **not** approved.

Chemistry 30 consists of four units of study:

A. Thermochemical Changes
B. Electrochemical Changes
C. Chemical Changes of Organic Compounds
D. Chemical Equilibrium Focusing on Acid-Base Systems

Attitude Outcomes

Students will be encouraged to develop positive attitudes that support the responsible acquisition and application of knowledge related to science and technology. The following attitude outcomes are to be developed throughout Chemistry 30, in conjunction with the specific outcomes for Knowledge; Science, Technology and Society (STS); and Skills in each unit.

Interest in Science

Students will be encouraged to:
show interest in science-related questions and issues and confidently pursue personal interests and career possibilities within science-related fields; *e.g.,*

- *appreciate how scientific problem solving and the development of new technologies are related*
- *recognize the contributions of science and technology to the progress of civilizations*
- *demonstrate interest in science and technology topics related to everyday life*
- *recognize the usefulness of being skilled at mathematics and problem solving*
- *explore where further science- and technology-related studies and careers can be pursued*
- *investigate careers in the fields of research and industry.*

Mutual Respect

Students will be encouraged to:
appreciate that scientific understanding evolves from the interaction of ideas involving people with different views and backgrounds; *e.g.,*

- *use a multiperspective approach, considering scientific, technological, economic, cultural, political and environmental factors when formulating conclusions, solving problems or making decisions on an STS issue*
- *recognize the contributions of various peoples and cultures in advancing understanding and applications of chemistry*
- *recognize that the scientific approach is one of many ways of viewing the universe*
- *recognize the research contributions of both men and women*
- *develop an interest in global energy issues and the effectiveness of local activities in contributing to the solution of problems related to energy.*

Scientific Inquiry

Students will be encouraged to:
seek and apply evidence when evaluating alternative approaches to investigations, problems and issues; *e.g.,*

- *value the need for accuracy and precision in data collection*
- *appreciate the creativity and perseverance required to develop workable solutions to problems*
- *tolerate the uncertainty involved in experimentation*
- *appreciate that knowledge of chemistry has been enhanced by evidence obtained from the application of technology, particularly instruments for making measurements and managing data*
- *research alternative models, explanations and theories when confronted with discrepant events*
- *evaluate, critically, inferences and conclusions and recognize bias, being aware of the many variables involved in experimentation*
- *appreciate the importance of careful laboratory techniques and precise calculations in obtaining accurate results.*

Collaboration

Students will be encouraged to:
work collaboratively in planning and carrying out investigations and in generating and evaluating ideas; *e.g.,*

- *assume a variety of roles within a group, as required*
- *accept responsibility for any task that helps the group complete an activity*
- *evaluate the ideas of others objectively*
- *seek the points of view of others and consider a multitude of perspectives.*

Stewardship

Students will be encouraged to:
demonstrate sensitivity and responsibility in pursuing a balance between the needs of humans and a sustainable environment; *e.g.,*

- *consider a variety of perspectives when addressing issues related to energy use, weighing scientific, technological and ecological factors*
- *develop a sense of responsibility toward the use of energy*
- *develop a sense of responsibility regarding the use and disposal of chemicals and materials*
- *identify and evaluate ways of using chemical potential energy sources efficiently*
- *develop an awareness that the application of technology has risks and benefits*
- *evaluate the contributions of technological innovations to quality of life and care of the environment*
- *evaluate the choices that scientists and technologists make when carrying out controversial research.*

Safety

Students will be encouraged to:
show concern for safety in planning, carrying out and reviewing activities, referring to the Workplace Hazardous Materials Information System (WHMIS) and consumer product labelling information; *e.g.,*

- *include safety as a requirement in scientific and technological endeavours*
- *use equipment and materials appropriately*
- *assume responsibility for the safety of all those who share a common working environment*
- *use minimal quantities of chemicals when performing experiments*
- *keep the workstation uncluttered, ensuring that only appropriate laboratory materials are present*
- *clean up after an activity and dispose of materials in a safe place, according to safety guidelines.*

Unit A: Thermochemical Changes

Themes: Energy, Change and Systems

Overview: In this unit, students study energy as it relates to chemical changes and quantify the energy involved in thermochemical systems, and consider the various aspects of energy use on society.

This unit builds on:
- Grade 7 Science, Unit C: Heat and Temperature
- Science 10, Unit A: Energy and Matter in Chemical Change and Unit D: Energy Flow in Global Systems

Unit A will require approximately 20% of the time allotted for Chemistry 30.

Links to Mathematics: The following mathematics topics are related to the content of Unit A but are not considered prerequisites.

Topics:	These topics may be found in the following courses:
• linear equations	Pure Mathematics 10, specific outcome 2.7; Applied Mathematics 10, specific outcome 5.1
• measurement	Applied Mathematics 10, specific outcomes 1.2 and 1.3; Applied Mathematics 20, specific outcomes 6.2, 6.3 and 6.4

Focusing Questions: How does our society use the energy of chemical changes? What are the impacts of energy use on society and the environment? How do chemists determine how much energy will be produced or absorbed for a given chemical reaction?

General Outcomes: There are two major outcomes in this unit.

Students will:

1. determine and interpret energy changes in chemical reactions
2. explain and communicate energy changes in chemical reactions.

Key Concepts: The following concepts are developed in this unit and may also be addressed in other units or in other courses. The intended level and scope of treatment is defined by the outcomes.
- enthalpy of formation
- enthalpy of reaction
- ΔH notation
- Hess' law
- molar enthalpy
- energy diagrams
- activation energy
- catalysts
- calorimetry
- fuels and energy efficiency

General Outcome 1
Students will determine and interpret energy changes in chemical reactions.

Specific Outcomes for Knowledge

Students will:

30–A1.1k	recall the application of $Q = mc\Delta t$ to the analysis of heat transfer
30–A1.2k	explain, in a general way, how stored energy in the chemical bonds of hydrocarbons originated from the sun
30–A1.3k	define enthalpy and molar enthalpy for chemical reactions
30–A1.4k	write balanced equations for chemical reactions that include energy changes
30–A1.5k	use and interpret ΔH notation to communicate and calculate energy changes in chemical reactions
30–A1.6k	predict the enthalpy change for chemical equations using standard enthalpies of formation
30–A1.7k	explain and use Hess' law to calculate energy changes for a net reaction from a series of reactions
30–A1.8k	use calorimetry data to determine the enthalpy changes in chemical reactions
30–A1.9k	identify that liquid water and carbon dioxide gas are reactants in photosynthesis and products of cellular respiration and that gaseous water and carbon dioxide gas are the products of hydrocarbon combustion in an open system
30–A1.10k	classify chemical reactions as endothermic or exothermic, including those for the processes of photosynthesis, cellular respiration and hydrocarbon combustion.

Specific Outcomes for Science, Technology and Society (STS) (Science and Technology Emphasis)

Students will:

30–A1.1sts explain that the goal of technology is to provide solutions to practical problems **(ST1) [ICT F2–4.4]**

- *provide examples of personal reliance on the chemical potential energy of matter, such as the use of fossil fuels*
- *identify ways to use energy more efficiently*
- *identify and explain the selection of different fuels used by communities in urban, rural and remote areas, and compare that selection to the fuels used by the early inhabitants of a particular area of Alberta*

30–A1.2sts explain that technological problems often require multiple solutions that involve different designs, materials and processes and that have both intended and unintended consequences **(ST3) [ICT F3–4.1]**

- *explain the applications of fossil fuels, with examples from industries in Alberta*
- *evaluate the impact of the combustion of various energy sources, including fossil fuels and biomass, on personal health and the environment and describe the technologies used by early peoples to mitigate the harmful effects of combustion.*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 1
Students will determine and interpret energy changes in chemical reactions.

Specific Outcomes for Skills (Science and Technology Emphasis)

Initiating and Planning

Students will:

30–A1.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- design a method to compare the molar enthalpy change when burning two or more fuels *(e.g., octane, propane, ethanol and historic fuels such as seal or whale oil)*, identifying and controlling major variables **(IP–ST1, IP–ST2)**
- describe procedures for the safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information **(IP–ST3)**.

Performing and Recording

Students will:

30–A1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- perform calorimetry experiments to determine the molar enthalpy change of chemical reactions **(PR–NS3) [ICT C6–4.1]**
- use thermometers or temperature probes appropriately when measuring temperature changes **(PR–NS3, PR–ST3) [ICT C6–4.4]**
- *use a computer-based laboratory to compile and organize data from an experiment to demonstrate molar enthalpy change* **(PR–NS4) [ICT C6–4.2]**
- *select and integrate information from various print and electronic sources to create multiple-linked documents about the use of alternative fuels* **(PR–ST1) [ICT C1–4.1, P5–4.1]**.

Analyzing and Interpreting

Students will:

30–A1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- compare energy changes associated with a variety of chemical reactions through the analysis of data and energy diagrams **(AI–NS3) [ICT C7–4.2]**
- *manipulate and present data through the selection of appropriate tools, such as scientific instrumentation, calculators, databases or spreadsheets* **(AI–ST3) [ICT P2–4.1]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 1
Students will determine and interpret energy changes in chemical reactions.

Communication and Teamwork

Students will:

30–A1.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- use appropriate International System of Units (SI) notation, fundamental and derived units and significant digits **(CT–ST2)**★
- use appropriate numeric, symbolic, graphical and linguistic modes of representation to communicate ideas, plans and results **(CT–ST2)**★
- *use advanced menu features within word processing software to accomplish a task and to insert tables, graphs, text and graphics* **(CT–ST2) [ICT P4–4.3]**.

★ To be developed throughout the course.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will explain and communicate energy changes in chemical reactions.

Specific Outcomes for Knowledge

Students will:

30–A2.1k define activation energy as the energy barrier that must be overcome for a chemical reaction to occur

30–A2.2k explain the energy changes that occur during chemical reactions, referring to bonds breaking and forming and changes in potential and kinetic energy

30–A2.3k analyze and label energy diagrams of a chemical reaction, including reactants, products, enthalpy change and activation energy

30–A2.4k explain that catalysts increase reaction rates by providing alternate pathways for changes, without affecting the net amount of energy involved; *e.g., enzymes in living systems.*

Specific Outcomes for Science, Technology and Society (STS) (Science and Technology Emphasis)

Students will:

30–A2.1sts explain that the goal of technology is to provide solutions to practical problems **(ST1) [ICT F2–4.4]**

- *explain how catalysts, such as catalytic converters on automobiles, reduce air pollution resulting from the burning of fuels*

30–A2.2sts explain that the appropriateness, risks and benefits of technologies need to be assessed for each potential application from a variety of perspectives, including sustainability **(ST7) [ICT F2–4.2, F3–4.1]**

- *assess, qualitatively, the risks and benefits of relying on fossil fuels as energy sources*

30–A2.3sts explain that the products of technology are devices, systems and processes that meet given needs; however, these products cannot solve all problems **(ST6) [ICT F3–4.1]**

- *evaluate the economic and environmental impacts of different fuels by relating carbon dioxide emissions and the heat content of a fuel.*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will explain and communicate energy changes in chemical reactions.

Specific Outcomes for Skills (Science and Technology Emphasis)

Initiating and Planning

Students will:

30–A2.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- describe procedures for the safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information **(IP–ST3)**
- *design an experimental procedure to illustrate the effect of a catalyst on a chemical reaction* **(IP–ST2)**.

Performing and Recording

Students will:

30–A2.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- draw enthalpy diagrams, indicating changes in energy for chemical reactions **(PR–NS4)**
- *use library and electronic research tools to compile information on the energy content of fuels used in Alberta power plants* **(PR–ST1) [ICT C1–4.1]**
- *design and build a heating device* **(PR–ST2)**.

Analyzing and Interpreting

Students will:

30–A2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- draw and interpret enthalpy diagrams for chemical reactions **(AI–NS2) [ICT C7–4.2]**
- explain the discrepancy between the theoretical and actual efficiency of a thermal energy conversion system **(AI–NS3)**
- *determine the efficiency of thermal energy conversion systems* **(AI–NS3)**
- *assess whether coal or natural gas should be used to fuel thermal power plants in Alberta* **(AI–ST2)**
- *evaluate a personally designed and constructed heating device, including a calculation of its efficiency* **(AI–ST2)**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will explain and communicate energy changes in chemical reactions.

Communication and Teamwork

Students will:

30–A2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- use appropriate SI notation, fundamental and derived units and significant digits to calculate and communicate enthalpy changes **(CT–ST2)**
- *work cooperatively with others to develop a plan to build an energy conversion device and seek feedback, test and review the plan, make revisions and implement the plan* **(CT–ST1)**
- *use advanced menu features within word processing software to accomplish a task and to insert tables, graphs, text and graphics* **(CT–SEC2) [ICT P4–4.3]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

Unit B: Electrochemical Changes

Themes: Change and Energy

Overview: In this unit, students study electrochemical change and analyze the matter and energy changes within a system.

This unit builds on:
- Science 9, Unit D: Electrical Principles and Technologies
- Science 10, Unit A: Energy and Matter in Chemical Change
- Chemistry 20, Unit A: The Diversity of Matter and Chemical Bonding and Unit D: Quantitative Relationships in Chemical Changes

Unit B will require approximately 30% of the time allotted for Chemistry 30.

Links to Mathematics: The following mathematics topics are related to the content of Unit B but are not considered prerequisites.

Topics:	These topics may be found in the following courses:
• linear equations	Pure Mathematics 10, specific outcome 2.7; Applied Mathematics 10, specific outcome 5.1
• measurement	Applied Mathematics 10, specific outcomes 1.2 and 1.3; Applied Mathematics 20, specific outcomes 6.2, 6.3 and 6.4

Focusing Questions: What is an electrochemical change? How have scientific knowledge and technological innovation been integrated into the field of electrochemistry?

General Outcomes: There are two major outcomes in this unit.

Students will:

1. explain the nature of oxidation-reduction reactions
2. apply the principles of oxidation-reduction to electrochemical cells.

Key Concepts: The following concepts are developed in this unit and may also be addressed in other units or in the courses. The intended level and scope of treatment is defined by the outcomes.

- oxidation
- reduction
- oxidizing agent
- reducing agent
- oxidation-reduction (redox) reaction
- oxidation number
- half-reaction
- disproportionation
- spontaneity
- standard reduction potential
- voltaic cell
- electrolytic cell
- electrolysis
- standard cell potential
- Faraday's law
- corrosion

General Outcome 1
Students will explain the nature of oxidation-reduction reactions.

Specific Outcomes for Knowledge

Students will:

30–B1.1k define oxidation and reduction operationally and theoretically

30–B1.2k define oxidizing agent, reducing agent, oxidation number, half-reaction, disproportionation

30–B1.3k differentiate between redox reactions and other reactions, using half-reactions and/or oxidation numbers

30–B1.4k identify electron transfer, oxidizing agents and reducing agents in redox reactions that occur in everyday life, in both living systems (*e.g., cellular respiration, photosynthesis*) and nonliving systems; i.e., corrosion

30–B1.5k compare the relative strengths of oxidizing and reducing agents, using empirical data

30–B1.6k predict the spontaneity of a redox reaction, based on standard reduction potentials, and compare their predictions to experimental results

30–B1.7k write and balance equations for redox reactions in acidic and neutral solutions by
- using half-reaction equations obtained from a standard reduction potential table
- developing simple half-reaction equations from information provided about redox changes
- assigning oxidation numbers, where appropriate, to the species undergoing chemical change

30–B1.8k perform calculations to determine quantities of substances involved in redox titrations.

Specific Outcomes for Science, Technology and Society (STS) (Science and Technology Emphasis)

Students will:

30–B1.1sts explain how the goal of technology is to provide solutions to practical problems **(ST1) [ICT F2–4.4]**
- describe the methods and devices used to prevent corrosion; i.e., physical coatings and cathodic protection
- *describe how the process of trial and error was used by early peoples to extract metals from ore*

30–B1.2sts explain that technological problems often require multiple solutions that involve different designs, materials and processes and that have both intended and unintended consequences **(ST3) [ICT F3–4.1]**
- *analyze redox reactions used in industry and commerce, such as pulp and paper, textiles, water treatment and food processing.*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 1
Students will explain the nature of oxidation-reduction reactions.

Specific Outcomes for Skills (Science and Technology Emphasis)

Initiating and Planning

Students will:

30–B1.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- design an experiment to determine the reactivity of various metals **(IP–NS1, IP–NS2, IP–NS3) [ICT C6–4.5]**
- describe procedures for the safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information **(IP–ST3)**.

Performing and Recording

Students will:

30–B1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- select and correctly use the appropriate equipment to perform a redox titration experiment **(PR–NS2, PR–NS3) [ICT C6–4.5, F1–4.2]**
- use a standard reduction potential table as a tool when considering the spontaneity of redox reactions and their products **(PR–ST3)**
- *create charts, tables or spreadsheets that present the results of redox experiments* **(PR–NS4) [ICT P2–4.1]**.

Analyzing and Interpreting

Students will:

30–B1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- evaluate data from an experiment to derive a simple reduction table **(AI–ST3, AI–NS4)**
- *interpret patterns and trends in data derived from redox reactions* **(A1–NS2) [ICT C7–4.2]**
- *identify the limitations of data collected from redox experiments* **(A1–NS4)**.

Communication and Teamwork

Students will:

30–B1.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- select and use appropriate numeric, symbolic, graphical and linguistic modes of representation to communicate equations for redox reactions and answers to problems related to redox titrations **(CT–ST2)**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will apply the principles of oxidation-reduction to electrochemical cells.

Specific Outcomes for Knowledge

Students will:

30–B2.1k define anode, cathode, anion, cation, salt bridge/porous cup, electrolyte, external circuit, power supply, voltaic cell and electrolytic cell

30–B2.2k identify the similarities and differences between the operation of a voltaic cell and that of an electrolytic cell

30–B2.3k predict and write the half-reaction equation that occurs at each electrode in an electrochemical cell

30–B2.4k recognize that predicted reactions do not always occur; *e.g., the production of chlorine gas from the electrolysis of brine*

30–B2.5k explain that the values of standard reduction potential are all relative to 0 volts, as set for the hydrogen electrode at standard conditions

30–B2.6k calculate the standard cell potential for electrochemical cells

30–B2.7k predict the spontaneity or nonspontaneity of redox reactions, based on standard cell potential, and the relative positions of half-reaction equations on a standard reduction potential table

30–B2.8k calculate mass, amounts, current and time in single voltaic and electrolytic cells by applying Faraday's law and stoichiometry.

Specific Outcomes for Science, Technology and Society (STS) (Science and Technology Emphasis)

Students will:

30–B2.1sts explain that scientific knowledge may lead to the development of new technologies, and new technologies may lead to or facilitate scientific discovery **(ST4) [ICT F2–4.4, F2–4.8]**

- *analyze the relationship of scientific knowledge and technological development in the applications of voltaic and electrolytic cells in such applications as batteries, electroplating, refining metals from ores, electrowinning and sanitizing swimming pools with chlorine compounds*

30–B2.2sts describe science and technology applications that have developed in response to human and environmental needs **(ST6) [ICT F3–4.1]**

- *investigate the use of technology, such as galvanism, metallurgy, magnesium coupling, painting, cathodic protection, to solve practical problems related to corrosion*

30–B2.3sts explain that science and technology have influenced, and been influenced by, historical development and societal needs (**SEC2**) **[ICT F2–4.4, F2–4.8]**

- *evaluate the economic importance to modern society of electrochemical cells, particularly fuel cells, and predict their future importance in transportation, the recycling of metals and the reduction of emissions from smokestacks.*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will apply the principles of oxidation-reduction to electrochemical cells.

Specific Outcomes for Skills (Science and Technology Emphasis)

Initiating and Planning

Students will:

30–B2.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- design an experiment, including a labelled diagram, to test predictions regarding spontaneity, products and the standard cell potential for reactions occurring in electrochemical cells **(IP–NS1, IP–NS2, IP–NS3)**
- describe procedures for the safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information **(IP–ST3)**
- *develop a plan to build a battery and seek feedback, test and review the plan and make revisions to the plan* **(IP–ST2)**.

Performing and Recording

Students will:

30–B2.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- construct and observe electrochemical cells **(PR–ST2, PR–ST3, PR–NS5)**
- *investigate the issue of the disposal of used batteries and propose alternative solutions to this problem* **(PR–ST1, AI–ST2) [ICT C2–4.1]**
- *compile and display evidence and information about voltaic and electrolytic cells in a variety of formats, including diagrams, flowcharts, tables, graphs and scatterplots* **(PR–NS4) [ICT P2–4.1]**.

Analyzing and Interpreting

Students will:

30–B2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- identify the products of electrochemical cells **(AI–ST3)**
- compare predictions with observations of electrochemical cells **(AI–ST3)**
- identify the limitations of data collected on an electrochemical cell **(AI–NS4)**
- explain the discrepancies between the theoretical and actual cell potential **(AI–NS4)**
- *evaluate the efficiencies and practicalities of various electrochemical cells for use as batteries* **(AI–ST1)**
- *evaluate experimental designs for voltaic and electrolytic cells and suggest improvements and alternatives* **(AI–ST1)**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will apply the principles of oxidation-reduction to electrochemical cells.

Communication and Teamwork

Students will:

30–B2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- use appropriate SI notation, fundamental and derived units and significant digits to communicate answers to problems related to functioning electrochemical cells **(CT–ST2)**
- *create multiple-linked documents, selecting and integrating information from various print and electronic sources or from several parts of the same source, to prepare a presentation on the use of hydrogen fuel cells for transportation and heating* **(CT–SEC2) [ICT C1–4.1, C1–4.4, PS–4.1]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

Unit C: Chemical Changes of Organic Compounds

Themes: Change, Diversity and Energy

Overview: In this introduction to organic chemistry, students learn about common organic compounds and describe their properties and reactions. The significance of organic chemistry, in the context of technological applications and quality of life, is explored.

This unit builds on:
- Chemistry 20, Unit A: The Diversity of Matter and Chemical Bonding

Unit C will require approximately 20% of the time allotted for Chemistry 30.

Links to Mathematics: None.

Focusing Questions: What are the common organic compounds and what is the system for naming them? How does society rely on organic compounds? How can society ensure that the technical applications of organic chemistry are assessed to ensure future quality of life and a sustainable environment?

General Outcomes: There are two major outcomes in this unit.

Students will:

1. explore organic compounds as a common form of matter
2. describe chemical reactions of organic compounds.

Key Concepts: The following concepts are developed in this unit and may also be addressed in other units or in other courses. The intended level and scope of treatment is defined by the learning outcomes.
- organic compounds
- naming organic compounds
- structural formulas
- structural isomers
- monomers
- polymers
- aliphatic and aromatic compounds
- saturated/unsaturated hydrocarbons
- functional groups identifying alcohols, carboxylic acids, esters and halogenated hydrocarbons
- esterification
- combustion reactions
- polymerization
- addition, substitution
- elimination

General Outcome 1
Students will explore organic compounds as a common form of matter.

Specific Outcomes for Knowledge

Students will:

30–C1.1k define organic compounds as compounds containing carbon, recognizing inorganic exceptions such as carbonates, cyanides, carbides and oxides of carbon

30–C1.2k identify and describe significant organic compounds in daily life, demonstrating generalized knowledge of their origins and applications; *e.g., methane, methanol, ethane, ethanol, ethanoic acid, propane, benzene, octane, glucose, polyethylene*

30–C1.3k name and draw structural, condensed structural and line diagrams and formulas, using International Union of Pure and Applied Chemistry (IUPAC) nomenclature guidelines, for saturated and unsaturated aliphatic (including cyclic) and aromatic carbon compounds
- containing up to 10 carbon atoms in the parent chain (*e.g., pentane; 3-ethyl-2,4-dimethylpentane*) or cyclic structure (*e.g., cyclopentane*)
- containing only one type of a functional group (with multiple bonds categorized as a functional group; *e.g., pent-2-ene*), including simple halogenated hydrocarbons (*e.g., 2-chloropentane*), alcohols (*e.g., pentan-2-ol*), carboxylic acids (*e.g., pentanoic acid*) and esters (*e.g., methyl pentanoate*), and with multiple occurrences of the functional group limited to halogens (*e.g., 2-bromo-1-chloropentane*) and alcohols (*e.g., pentane-2,3-diol*)

30–C1.4k identify types of compounds from the hydroxyl, carboxyl, ester linkage and halogen functional groups, given the structural formula

30–C1.5k define structural isomerism as compounds having the same empirical formulas, but with different structural formulas, and relate the structures to variations in the properties of the isomers

30–C1.6k compare, both within a homologous series and among compounds with different functional groups, the boiling points and solubility of examples of aliphatics, aromatics, alcohols and carboxylic acids

30–C1.7k describe, in general terms, the physical, chemical and technological processes (fractional distillation and solvent extraction) used to separate organic compounds from natural mixtures or solutions; *e.g., petroleum refining, bitumen recovery*.

Specific Outcomes for Science, Technology and Society (STS) (Social and Environmental Contexts Emphasis)

Students will:

30–C1.1sts explain how science and technology are developed to meet societal needs and expand human capability **(SEC1) [ICT F2–4.4, F2–4.8]**
- *describe where organic compounds are used in processes and common products, such as in hydrogenation to produce margarine and esters used as flavouring agents*
- *describe Aboriginal use of organic substances for waterproofing, tanning, dyeing, medicines, salves and insect repellents*

30–C1.2sts explain that science and technology have influenced, and been influenced by, historical development and societal needs **(SEC2) [ICT F2–4.8]**
- *explain how, as a result of chemistry and chemical technology, synthetic compounds of great benefit to society, such as plastics, medicines, hydrocarbon fuels and pesticides, have been produced.*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 1
Students will explore organic compounds as a common form of matter.

Specific Outcomes for Skills (Social and Environmental Contexts Emphasis)

Initiating and Planning

Students will:

30–C1.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- design a procedure to identify types of organic compounds **(IP–NS1, IP–NS2, IP–NS3)**
- describe procedures for the safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information **(IP–SEC3)**
- design a procedure to separate a mixture of organic compounds, based on boiling point differences **(IP–ST2, IP–ST3)**.

Performing and Recording

Students will:

30–C1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- build molecular models depicting the structures of selected organic and inorganic compounds **(PR–NS4) [ICT C6–4.4]**
- perform an experiment to compare the properties of organic compounds with inorganic compounds, considering properties such as solubility, viscosity, density, conductivity, reactivity **(PR–NS2, PR–NS3, PR–NS5)**.

Analyzing and Interpreting

Students will:

30–C1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- follow appropriate IUPAC guidelines when writing the names and formulas of organic compounds **(AI–NS1)**
- compile and organize data to compare the properties of structural isomers; *e.g., pairs of hydrocarbon isomers and primary, secondary and tertiary alcohols* **(AI–NS1) [ICT C6–4.2]**
- interpret the results of a test to distinguish between a saturated and an unsaturated aliphatic, using aqueous bromine or potassium permanganate solutions **(AI–NS2)**
- *analyze the contributions and limitations of scientific and technological knowledge in societal decision making, in relation to the costs and benefits of societal use of petrochemicals, pharmaceuticals and pesticides* **(AI–SEC2) [ICT F3–4.1]**
- *explore aspects of present-day reliance on extracted or synthesized nutrients, with consideration of the synergy of compounds (reliance on vitamin supplements, meal replacements and nutraceuticals versus traditional methods of consuming natural foods)* **(AI–SEC2)**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 1
Students will explore organic compounds as a common form of matter.

Communication and Teamwork

Students will:

30–C1.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- *use advanced menu features within word processing software to accomplish a task and to insert tables, graphs, text and graphics* **(CT–SEC2) [ICT P4–4.3]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will describe chemical reactions of organic compounds.

Specific Outcomes for Knowledge

Students will:

30–C2.1k define, illustrate and provide examples of simple addition, substitution, elimination, esterification and combustion reactions

30–C2.2k predict products and write and interpret balanced equations for the above reactions

30–C2.3k define, illustrate and provide examples of monomers *(e.g., ethylene)*, polymers *(e.g., polyethylene)* and polymerization in living systems *(e.g., carbohydrates, proteins)* and nonliving systems *(e.g., nylon, polyester, plastics)*

30–C2.4k relate the reactions described above to major reactions that produce thermal energy and economically important compounds from fossil fuels.

Specific Outcomes for Science, Technology and Society (STS) (Social and Environmental Contexts Emphasis)

Students will:

30–C2.1sts explain how science and technology are developed to meet societal needs and expand human capability **(SEC1)**

- *describe processes for obtaining economically important compounds from fossil fuels; e.g.,*
  - *compare hydrocracking and catalytic reforming*
  - *describe bitumen upgrading*
- *describe major reactions used in the petrochemical industry in Alberta, such as in the production of methanol, ethylene glycol, polyethylene, polyvinyl chloride (PVC) and urea formaldehyde*
- *investigate the application of nanoscience and nanotechnology in the petrochemical industry and the medical sciences*

30–C2.2sts explain that science and technology have influenced, and been influenced by, historical development and societal needs **(SEC2) [ICT F2–4.8]**

- *describe processes involved in producing fuels; e.g.,*
  - *adjusting octane/cetane rating*
  - *reducing sulfur content*
  - *adding compounds such as oxygenated additives (blending with ethanol)*

30–C2.3sts explain how science and technology have both intended and unintended consequences for humans and the environment **(SEC3) [ICT F3–4.1]**

- *assess the positive and negative effects of various reactions involving organic compounds, relating these processes to quality of life and potential health and environmental issues; e.g.,*
  - *burning fossil fuels and climate change*
  - *production of pharmaceuticals and foods*
  - *by-products (CO_2, dioxins) of common reactions*
  - *recycling of plastics*
  - *impact of chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons(HCFCs) on the ozone layer*
  - *transfats in the diet*
- *evaluate the implications of the development of nanoscience and nanotechnology, for application in the petrochemical industry and the medical sciences, on society and the environment.*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will describe chemical reactions of organic compounds.

Specific Outcomes for Skills (Social and Environmental Contexts Emphasis)

Initiating and Planning

Students will:

30–C2.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- predict the ester formed from an alcohol and an organic acid **(IP–NS3)**
- describe procedures for the safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information **(IP–SEC3)**
- *design a procedure to prepare a polymer* **(IP–NS1).**

Performing and Recording

Students will:

30–C2.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- perform an experiment to investigate the reactions of organic compounds; *e.g.,*
  - *synthesize a polymer, such as nylon or "slime"*
  - *produce an ester*
  - *investigate methods of making soap*

  (IP–NS1, IP–NS2, IP–NS3, IP–NS4)
- use library and electronic research tools to collect information on:
  - *bitumen upgrading*
  - *the octane/cetane ratings of fuels and how they are determined*
  - *the costs and benefits of supporting the petrochemical industry*

  (PR–SEC1, PR–SEC2) [ICT C1–4.1].

Analyzing and Interpreting

Students will:

30–C2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- use IUPAC conventions when writing organic chemical reactions **(AI–NS1)**
- investigate the issue of greenhouse gases; identify some greenhouse gases, including methane, carbon dioxide, water and dinitrogen oxide (nitrous oxide); and analyze their contribution to climate change **(AI–SEC1, AI–SEC2) [ICT F3–4.1]**
- draw or use models to illustrate polymers **(CT–ST2)**
- *analyze a process for producing polymers* **(AI–ST1)**
- *analyze efficiencies and negative by-products related to chemical processes in organic chemistry* **(AI–ST2) [ICT F3–4.1]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will describe chemical reactions of organic compounds.

Communication and Teamwork

Students will:

30–C2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- *use advanced menu features within word processing software to insert tables, graphs, text and graphics when preparing a report on an issue related to society's use of organic chemistry* **(CT–SEC2) [ICT P4–4.3]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

Unit D: Chemical Equilibrium Focusing on Acid-Base Systems

Themes: Change, Systems and Equilibrium

Overview: In this unit, the concept that chemical change eventually attains equilibrium is developed, followed by a focus on the quantitative treatment of reaction systems involving acid-base solutions.

This unit builds on:

- Science 8, Unit A: Mix and Flow of Matter
- Science 9, Unit B: Matter and Chemical Change
- Science 10, Unit A: Energy and Matter in Chemical Change
- Chemistry 20, Unit C: Matter as Solutions, Acids and Bases and Unit D: Quantitative Relationships in Chemical Changes

Unit D will require approximately 30% of the time allotted for Chemistry 30.

Links to Mathematics: The following mathematics topics are related to the content of Unit D but are not considered prerequisites.

Topics:	These topics may be found in the following courses:
• linear equations	Pure Mathematics 10, specific outcome 2.7; Applied Mathematics 10, specific outcome 5.1
• plotting nonlinear data	Pure Mathematics 10, specific outcome 3.1; Applied Mathematics 10, specific outcome 3.1
• solving nonlinear equations	Pure Mathematics 20, specific outcomes 2.1, 2.3, 2.4, and 3.1
• measurement	Applied Mathematics 10, specific outcomes 1.2 and 1.3; Applied Mathematics 20, specific outcomes 6.2, 6.3 and 6.4

Focusing Questions: What is happening in a system at equilibrium? How do scientists predict shifts in the equilibrium of a system? How do Brønsted–Lowry acids and bases illustrate equilibrium?

General Outcomes: There are two major outcomes in this unit.

Students will:

1. explain that there is a balance of opposing reactions in chemical equilibrium systems
2. determine quantitative relationships in simple equilibrium systems.

Key Concepts: The following concepts are developed in this unit and may also be addressed in other units or in other courses. The intended level and scope of treatment is defined by the outcomes.

- chemical equilibrium systems
- reversibility of reactions
- Le Chatelier's principle
- equilibrium law expression
- equilibrium constants K_c , K_{w} , K_{a} , K_{b}
- acid-base equilibrium
- Brønsted–Lowry acids and bases
- titration curves
- conjugate pairs of acids and bases
- amphiprotic substances
- buffers
- indicators

General Outcome 1
Students will explain that there is a balance of opposing reactions in chemical equilibrium systems.

Specific Outcomes for Knowledge

Students will:

30–D1.1k define equilibrium and state the criteria that apply to a chemical system in equilibrium; i.e., closed system, constancy of properties, equal rates of forward and reverse reactions

30–D1.2k identify, write and interpret chemical equations for systems at equilibrium

30–D1.3k predict, qualitatively, using Le Chatelier's principle, shifts in equilibrium caused by changes in temperature, pressure, volume, concentration or the addition of a catalyst and describe how these changes affect the equilibrium constant

30–D1.4k define K_c to predict the extent of the reaction and write equilibrium-law expressions for given chemical equations, using lowest whole-number coefficients

30–D1.5k describe Brønsted–Lowry acids as proton donors and bases as proton acceptors

30–D1.6k write Brønsted–Lowry equations, including indicators, and predict whether reactants or products are favoured for acid-base equilibrium reactions for monoprotic and polyprotic acids and bases

30–D1.7k identify conjugate pairs and amphiprotic substances

30–D1.8k define a buffer as relatively large amounts of a weak acid or base and its conjugate in equilibrium that maintain a relatively constant pH when small amounts of acid or base are added.

Specific Outcomes for Science, Technology and Society (STS) (Nature of Science Emphasis)

Students will:

30–D1.1sts explain that the goal of science is knowledge about the natural world **(NS1)**
- *apply equilibrium theories and principles to analyze a variety of phenomena; e.g.,*
  - *carbon dioxide escaping from an open bottle/can of carbonated beverage*
  - *role of the oceans in the carbon cycle*
  - *solubility of oxygen gas in lake water*
  - *acid precipitation (deposition)*
  - *blood gases in deep-sea diving*
  - *buffers in living systems*

30–D1.2sts explain that scientific knowledge and theories develop through hypotheses, the collection of evidence, investigation and the ability to provide explanations **(NS2)**
- *research how equilibrium theories and principles developed*

30–D1.3sts explain that the goal of technology is to provide solutions to practical problems **(ST1)** **[ICT F2–4.4]**
- *analyze how equilibrium principles have been applied in industrial processes; e.g.,*
  - *Haber–Bosch process for producing ammonia*
  - *Solvay process for producing sodium carbonate*
  - *production of methanol.*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 1
Students will explain that there is a balance of opposing reactions in chemical equilibrium systems.

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

Students will:

30–D1.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- predict variables that can cause a shift in equilibrium **(IP–NS3)**
- design an experiment to show equilibrium shifts; *e.g., colour change, temperature change, precipitation* **(IP–NS2)**
- describe procedures for the safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information **(IP–NS4)**
- *design a procedure to prepare a system capable of buffering* **(PR–ST2)**.

Performing and Recording

Students will:

30–D1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- perform an experiment to test, qualitatively, predictions of equilibrium shifts; *e.g., colour change, temperature change, precipitation and gas production* **(PR–NS3, PR–NS4, PR–NS5)**
- *prepare a buffer and investigate its relative abilities, with a control (i.e., water), to resist a pH change when a small amount of strong acid or strong base is added* **(AI–NS6)**.

Analyzing and Interpreting

Students will:

30–D1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- write the equilibrium law expression for a given equation **(AI–NS1)**
- analyze, qualitatively, the changes in concentrations of reactants and products after an equilibrium shift **(AI–NS6)**
- interpret data from a graph to determine when equilibrium is established and to determine the cause of a stress on the system **(AI–NS2, AI–NS6) [ICT C6–4.1]**
- interpret, qualitatively, titration curves of monoprotic and polyprotic acids and bases for strong acid–weak base and weak acid–strong base combinations, and identify buffering regions **(AI–NS2)**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 1
Students will explain that there is a balance of opposing reactions in chemical equilibrium systems.

Communication and Teamwork

Students will:

30–D1.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- *work cooperatively to develop an illustration and explanation of reversible reactions* **(CT–ST2)**
- *use advanced menu features within word processing software to insert tables, graphs, text and graphics when developing a group report on equilibrium systems* **(CT–SEC2) [ICT C1–4.4]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will determine quantitative relationships in simple equilibrium systems.

Specific Outcomes for Knowledge

Students will:

30–D2.1k recall the concepts of pH and hydronium ion concentration and pOH and hydroxide ion concentration, in relation to acids and bases

30–D2.2k define K_w, K_a, K_b and use these to determine pH, pOH, $[H_3O^+]$ and $[OH^-]$ of acidic and basic solutions

30–D2.3k calculate equilibrium constants and concentrations for homogeneous systems and Brønsted–Lowry acids and bases (excluding buffers) when

- concentrations at equilibrium are known
- initial concentrations and one equilibrium concentration are known
- the equilibrium constant and one equilibrium concentration are known.

Note: Examples that require the application of the quadratic equation are excluded; however, students may use this method when responding to open-ended questions.

Outcomes for Science, Technology and Society (STS) (Science and Technology Emphasis)

Students will:

30–D2.1sts explain that technological development may involve the creation of prototypes, the testing of prototypes and the application of knowledge from related scientific and interdisciplinary fields **(ST2)**

- *analyze, on the basis of chemical principles, the application of equilibrium*
  - *industrial processes or medical sciences*
  - *buffering in living systems*
  - *acid precipitation.*

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.

General Outcome 2
Students will determine quantitative relationships in simple equilibrium systems.

Specific Outcomes for Skills (Nature of Science Emphasis)

Initiating and Planning

Students will:

30–D2.1s formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues

- design an experiment to show qualitative equilibrium shifts in concentration under a given set of conditions **(IP–SEC3)**
- describe procedures for the safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information **(IP–NS4)**.

Performing and Recording

Students will:

30–D2.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information

- perform an experiment to show equilibrium shifts in concentration **(PR–NS3)** **[ICT C6–4.1]**.

Analyzing and Interpreting

Students will:

30–D2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions

- use experimental data to calculate equilibrium constants **(AI–NS3)**.

Communication and Teamwork

Students will:

30–D2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results

- *use advanced menu features within word processing software to insert tables, graphs, text and graphics when developing a group report on equilibrium applications in Alberta industries* **(CT–SEC2) [ICT C1–4.4]**.

Note: Some of the outcomes are supported by examples. The examples are written in italics and **do not form part of the required program** but are provided as an illustration of how the outcomes might be developed.