This document represents an updating of the 1995 IRP. This updating has been undertaken for the purpose of

- clarifying the Prescribed Learning Outcomes
- introducing Suggested Achievement Indicators
- addressing content overload

Resources previously recommended for the 1995 version of the curriculum, where still valid, continue to support this updated IRP. (See the Learning Resources section in this IRP for additional information.)

Chemistry 11 and 12

Integrated Resource Package 2006

British Columbia
The Best Place on Earth

Ministry of Education

IRP 141

Library and Archives Canada Cataloguing in Publication Data
Main entry under title:
Chemistry 11 and 12 : integrated resource package 2006

Also available on the Internet.
Includes bibliographical references: p.
ISBN 0-7726-5525-1

1. Chemistry – Study and teaching (Secondary) – British Columbia.
2. Education, Secondary – Curricula – British Columbia. I. British Columbia. Ministry of Education.

QD49.C32C43 2006 540.71'2711 C2006-960054-6

Acknowledgments

Preface

Introduction to Chemistry 11 and 12

Considerations for Program Delivery

Prescribed Learning Outcomes

Student Achievement

Learning Resources

This document has been updated from the 1995 IRP to include suggested achievement indicators, a more clear and succinct set of prescribed learning outcomes, a snapshot of the course's key elements, and other minor refinements, while maintaining the original intent and essence of the 1995 curricular content.

Many people contributed their expertise to the Chemistry 11-12 IRP. The Project Manager (2005-2006) was Mr. Waël Afifi of the Ministry of Education, working with other ministry personnel and our partners in education. We would like to thank all who participated in this process, including the teams of educators who developed the 1995 Chemistry 11-12 IRP, and the following individuals who contributed to the 2005-2006 updating of this document:

Jim Axford	School District No. 68 (Nanaimo)
Darrel Barber	School District No. 37 (Delta)
Matthew Bourget	School District No. 71 (Comox)
Gerrit Keizer	Simon Fraser University
Anne Laite	School District No. 46 (Sunshine Coast)
Jeanette Laursoo	Independent School (Mulgrave School, West Vancouver)
Barbara McKinley	School District No. 44 (North Vancouver)
Megan Ryan	School District No. 35 (Langley)
GT Publishing Services, Ltd.	project co-ordination, writing, and editing

This Integrated Resource Package (IRP) provides basic information teachers will require in order to implement Chemistry 11 and 12. This document supersedes the *Chemistry 11 and 12 Integrated Resource Package* (1995).

The information contained in this document is also available on the Internet at www.bced.gov.bc.ca/irp/irp.htm

The following paragraphs provide brief descriptions of the components of the IRP.

Introduction

The Introduction provides general information about Chemistry 11 and 12, including special features and requirements.

Included in this section are
- a rationale for teaching Chemistry 11 and 12 in BC schools
- information about graduation program requirements and provincial examinations
- listings of the curriculum organizers – groupings for prescribed learning outcomes that share a common focus
- suggested time allotments for each course

Considerations for Program Delivery

This section of the IRP contains additional information to help educators develop their school practices and plan their program delivery to meet the needs of all learners.

Prescribed Learning Outcomes

This section contains the *prescribed learning outcomes*, the legally required content standards for the provincial education system. The learning outcomes define the required knowledge, skills, and attitudes for each subject. They are statements of what students are expected to know and be able to do by the end of the course.

Student Achievement

This section of the IRP contains information about classroom assessment and measuring student achievement, including sets of specific achievement indicators for each prescribed learning outcome. Achievement indicators are statements that describe what students should be able to do in order to demonstrate that they fully meet the expectations set out by the prescribed learning outcomes. Achievement indicators are not mandatory; they are provided to assist in the assessment of how well students achieve the prescribed learning outcomes.

Also included in this section are key elements – descriptions of content that help determine the intended depth and breadth of the prescribed learning outcomes.

Learning Resources

This section contains general information on learning resources, and provides a link to titles, descriptions, and ordering information for the recommended learning resources in the Chemistry 11 and 12 Grade Collections.

INTRODUCTION

Chemistry 11 and 12

This Integrated Resource Package (IRP) sets out the provincially prescribed curriculum for Chemistry 11 and 12. The development of this IRP has been guided by the principles of learning:
- Learning requires the active participation of the student.
- People learn in a variety of ways and at different rates.
- Learning is both an individual and a group process.

In addition to these three principles, this document recognizes that British Columbia's schools include students of varied backgrounds, interests, abilities, and needs. Wherever appropriate for this curriculum, ways to meet these needs and to ensure equity and access for all learners have been integrated as much as possible into the learning outcomes and achievement indicators.

This document represents an updating of the 1995 IRP. This updating has been undertaken for the purpose of
- clarifying the prescribed learning outcomes
- introducing suggested achievement indicators
- addressing content overload

Resources previously recommended for the 1995 version of the curriculum continue to support this updated IRP. (See the Learning Resources section later in this IRP for additional information.)

Chemistry 11 and 12, in draft form, was available for public review and response from November to December, 2005. Feedback from educators, students, parents, and other educational partners informed the development of this updated IRP.

Rationale

The science curriculum of British Columbia provides a foundation for the scientific literacy of citizens, for the development of a highly skilled and adaptable work force, and for the development of new technologies. It is a foundation on which teachers can develop a science program that provides a comprehensive set of knowledge, skills, and experiences related to science.

School science programs that are planned to develop scientifically literate students provide experiences that
- help students become flexible and adaptable rather than focussing on acquiring specialized knowledge
- develop the capacity to think critically
- call for a wide range of knowledge, methods, and approaches that enable students to analyse personal and societal issues critically
- encourage students to examine the impact of scientific knowledge on their lives, society, and the environment
- develop a positive attitude toward science
- cultivate students' appreciation of the scientific endeavour and their potential to contribute to it

The science curriculum of British Columbia provides a framework of opportunities for students to become scientifically literate by
- examining basic concepts, principles, laws, and theories through scientific inquiry
- actively gaining knowledge, skills, and attitudes that provide the basis for sound and ethical problem solving and decision making
- developing an understanding of the place of science in society and history and its relationship to other disciplines
- making informed and responsible decisions about themselves, their homes, workplaces, and the global community

Chemistry is the science that deals with the properties and reactions of materials. It is concerned with the identification, characterization, and transformations of matter, and with the energy changes accompanying these transformations. As such, it makes an important contribution to our ability to
- comprehend the natural environment
- understand various other pure and applied sciences, as well as the nature of scientific inquiry

Through participation in co-operative labs, independent research, and other classroom experiences, students acquire knowledge, skills, and attitudes that enable them to pursue further study and experience success in the workplace as informed decision makers and full participants.

Requirements and Graduation Credits

Chemistry 11 and 12 are two of the courses available for students to satisfy the Grade 11-12 Graduation Program science requirement.

Chemistry 11 and 12 are each designated as four-credit courses, and must be reported as such to the Ministry of Education for transcript purposes. Letter grades and percentages must be reported for these courses. It is not possible to obtain partial credit for these courses.

The course codes for Chemistry 11 and 12 are CH 11 and CH 12. These courses are also available in French (Chimie 11, Chimie 12; course codes CHF 11, CHF 12).

Graduation Program Examination

Chemistry 12 has an optional Graduation Program examination, worth 40% of the final course mark for students who choose to write it. Although students are not required to take this exam to receive credit for the course, they should be advised that some post-secondary institutions require Grade 12 exams to meet entrance requirements, and that writing Grade 12 exams also provides opportunities for provincial scholarships.

For more information, refer to the Ministry of Education examinations web site: www.bced.gov.bc.ca/exams/

Curriculum Organizers

A curriculum organizer consists of a set of prescribed learning outcomes that share a common focus. The prescribed learning outcomes for Chemistry 11 and 12 are grouped under the following curriculum organizers.

Note that the ordering of these organizers is not intended to imply an order of instruction.

Chemistry 11	Chemistry 12
• Skills and Processes of Chemistry • The Nature of Matter • Mole Concept • Chemical Reactions • Atomic Theory • Solution Chemistry • Organic Chemistry	• Reaction Kinetics • Dynamic Equilibrium • Solubility Equilibria • Nature of Acids and Bases • Acids and Bases: Quantitative Problem Solving • Applications of Acid-Base Reactions • Oxidation-Reduction • Applications of Redox Reactions

Suggested Timeframe

Provincial curricula are developed in accordance with the amount of instructional time recommended by the Ministry of Education for each subject area. Teachers may choose to combine various curricula to enable students to integrate ideas and make meaningful connections.

Chemistry 11 and 12 each require approximately 90–110 hours of instructional time. Although a four-credit course is typically equivalent to 120 hours, this timeframe allows for flexibility to address local needs. The Student Achievement section of this IRP provides a suggested breakdown of this suggested time allotment by curriculum organizer.

Considerations for Program Delivery

Chemistry 11 and 12

This section of the IRP contains additional information to help educators develop their school practices and plan their program delivery to meet the needs of all learners. Included in this section is information about
- Alternative Delivery policy
- addressing local contexts
- involving parents and guardians
- course requirements respecting beliefs
- safety considerations
- confidentiality
- inclusion, equity, and accessibility for all learners
- working with the school and community
- working with the Aboriginal community
- information and communications technology
- copyright and responsibility

Alternative Delivery Policy

The Alternative Delivery policy does not apply to Chemistry 11 and 12.

The Alternative Delivery policy outlines how students, and their parents or guardians, in consultation with their local school authority, may choose means other than instruction by a teacher within the regular classroom setting for addressing prescribed learning outcomes contained in the Health curriculum organizer of the following curriculum documents:
- Health and Career Education K to 7, and Personal Planning K to 7 Personal Development curriculum organizer (until September 2008)
- Health and Career Education 8 and 9
- Planning 10

The policy recognizes the family as the primary educator in the development of children's attitudes, standards, and values, but the policy still requires that all prescribed learning outcomes be addressed and assessed in the agreed-upon alternative manner of delivery.

It is important to note the significance of the term "alternative delivery" as it relates to the Alternative Delivery policy. The policy does not permit schools to omit addressing or assessing any of the prescribed learning outcomes within the health and career education curriculum. Neither does it allow students to be excused from meeting any learning outcomes related to health. It is expected that students who arrange for alternative delivery will address the health-related learning outcomes and will be able to demonstrate their understanding of these learning outcomes.

For more information about policy relating to alternative delivery, refer to www.bced.gov.bc.ca/policy/

Addressing Local Contexts

There is some flexibility in the Chemistry 11 and 12 curriculum, providing opportunities for individual teacher and student choice in the selection of topics to meet learning outcomes. This flexibility enables educators to plan their programs by using topics and examples that are relevant to their local context and to the particular interests of their students. When selecting topics it may be appropriate to incorporate student input.

Involving Parents and Guardians

The family is the primary educator in the development of students' attitudes and values. The school plays a supportive role by focussing on the prescribed learning outcomes in the Chemistry 11 and 12 curriculum. Parents and guardians can support, enrich, and extend the curriculum at home.

It is highly recommended that schools inform parents and guardians about the Chemistry 11 and 12 curriculum, and teachers (along with school and district administrators) may choose to do so by
- informing parents/guardians and students of the prescribed learning outcomes for the subject by sending home class letters, providing an overview during parent-teacher interviews, etc.
- responding to parent and guardian requests to discuss course unit plans, learning resources, etc.

Course Requirements Respecting Beliefs

For many students and teachers, the study of some science concepts may lead to issues and questions that go beyond the immediate scope of curriculum (e.g., science is used to meet many industrial requirements, but industrial decision makers must consider factors other than scientific feasibility before adopting a particular process). The technological application of science in areas such as genetic engineering, human reproduction, and medical technology raises questions of ethics and values. Because these social questions arise, in part, from capabilities that science makes possible, they should be addressed. It must be made clear to students, however, that science only provides the background for what is hoped will be informed personal and social decisions. Teachers must handle these questions objectively and with sensitivity.

Reconciling scientific discoveries (for example, in age dating) and religious faith poses a particular challenge for some students. While respecting the personal beliefs of students, teachers should be careful to distinguish between knowledge based on the application of scientific methods, and religious teachings and associated beliefs such as creationism, theory of divine creation, or intelligent design theory.

Safety Considerations

Science education is an activity-based process that provides an exciting method of teaching and learning. However, experiments and demonstrations may involve inherent risks for both the teacher and the student.

Safety guidelines must be discussed with students. These safety guidelines must support and encourage the investigative approach generally and laboratory instruction specifically, while at the same time promoting safety in the classroom and laboratory. Encouraging a positive safety attitude is a responsibility shared among the board, school administrators, teachers, and students in every school district. The co-operation of all these groups helps develop a strong safety consciousness both inside and outside our schools.

Field work and field trips require special vigilance with respect to traffic and road safety, safe practices in study areas and when obtaining samples, and an awareness of changes in weather.

Another important aspect of in-school safety is the Workplace Hazardous Materials Information Systems (WHMIS). Through labelling, material safety data sheets, and education and training, WHMIS is designed to ensure that those using hazardous materials have sufficient information to handle them safely. Each school district should have an individual trained in WHMIS who can work with teachers to establish safe, well-ventilated classroom and laboratory working conditions.

To assist teachers in providing a safe science-learning environment, the Ministry of Education publishes the *Science Safety Resource Manual*, which has been distributed to every school.

The *Science Safety Resource Manual* is available online at
www.bced.gov.bc.ca/irp/resdocs/scisafety.htm

Confidentiality

The *Freedom of Information and Protection of Privacy Act* (FOIPPA) applies to students, to school districts, and to all curricula. Teachers, administrators, and district staff should consider the following:

- Be aware of district and school guidelines regarding the provisions of FOIPPA and how it applies to all subjects, including Chemistry 11 and 12.
- Do not use students' Personal Education Numbers (PEN) on any assignments that students wish to keep confidential.
- Ensure students are aware that if they disclose personal information that indicates they are at risk for harm, then that information cannot be kept confidential.
- Inform students of their rights under FOIPPA, especially the right to have access to their own personal information in their school records. Inform parents of their rights to access their children's school records.

- Minimize the type and amount of personal information collected, and ensure that it is used only for purposes that relate directly to the reason for which it is collected.
- Inform students that they will be the only ones recording personal information about themselves unless they, or their parents, have consented to teachers collecting that information from other people (including parents).
- Provide students and their parents with the reason(s) they are being asked to provide personal information in the context of the Chemistry 11 and 12 curriculum.
- Inform students and their parents that they can ask the school to correct or annotate any of the personal information held by the school, in accordance with Section 29 of FOIPPA.
- Ensure students are aware that their parents may have access to the schoolwork they create only insofar as it pertains to students' progress.
- Ensure that any information used in assessing students' progress is up-to-date, accurate, and complete.

For more information about confidentiality, refer to www.mser.gov.bc.ca/FOI_POP/index.htm

Inclusion, Equity, and Accessibility for All Learners

British Columbia's schools include students of varied backgrounds, interests, and abilities. The Kindergarten to Grade 12 school system focusses on meeting the needs of all students. When selecting specific topics, activities, and resources to support the implementation of Chemistry 11 and 12, teachers are encouraged to ensure that these choices support inclusion, equity, and accessibility for all students. In particular, teachers should ensure that classroom instruction, assessment, and resources reflect sensitivity to diversity and incorporate positive role portrayals, relevant issues, and themes such as inclusion, respect, and acceptance.

Government policy supports the principles of integration and inclusion of students for whom English is a second language and of students with special needs. Most of the prescribed learning outcomes and suggested achievement indicators in this IRP can be met by all students, including those with special needs and/or ESL needs. Some strategies may require adaptations to ensure that those with special and/or ESL needs can successfully achieve the learning outcomes. Where necessary, modifications can be made to the prescribed learning outcomes for students with Individual Education Plans.

For more information about resources and support for students with special needs, refer to www.bced.gov.bc.ca/specialed/

For more information about resources and support for ESL students, refer to www.bced.gov.bc.ca/esl/

Working with the School and Community

This curriculum addresses a wide range of skills and understandings that students are developing in other areas of their lives. It is important to recognize that learning related to this curriculum extends beyond the science classroom.

School and district-wide programs support and extend learning in Biology 11 and 12. Community organizations may also support the curriculum with locally developed learning resources, guest speakers, workshops, and field studies. Teachers may wish to draw on the expertise of these community organizations and members.

Working with the Aboriginal Community

The Ministry of Education is dedicated to ensuring that the cultures and contributions of Aboriginal peoples in BC are reflected in all provincial curricula. To address these topics in the classroom in a way that is accurate and that respectfully reflects Aboriginal concepts of teaching and learning, teachers are strongly encouraged to seek the advice and support of local Aboriginal communities. Aboriginal communities are diverse in terms of language, culture, and available resources, and each community will have its own unique protocol to gain support for integration of local knowledge and expertise. To begin discussion of possible instructional and assessment activities, teachers should first contact Aboriginal education co-ordinators, teachers, support workers, and counsellors in their district who will be able to facilitate the identification of local resources and contacts such as elders, chiefs, tribal or band councils, Aboriginal cultural centres, Aboriginal Friendship Centres, and Métis or Inuit organizations.

In addition, teachers may wish to consult the various Ministry of Education publications available, including the "Planning Your Program" section of the resource, *Shared Learnings*. This resource was developed to help all teachers provide students with knowledge of, and opportunities to share experiences with, Aboriginal peoples in BC.

For more information about these documents, consult the Aboriginal Education web site: www.bced.gov.bc.ca/abed/welcome.htm

Information and Communications Technology

The study of information and communications technology is increasingly important in our society. Students need to be able to acquire and analyse information, to reason and communicate, to make informed decisions, and to understand and use information and communications technology for a variety of purposes. Development of these skills is important for students in their education, their future careers, and their everyday lives.

Literacy in the area of information and communications technology can be defined as the ability to obtain and share knowledge through investigation, study, instruction, or transmission of information by means of media technology. Becoming literate in this area involves finding, gathering, assessing, and communicating information using electronic means, as well as developing the knowledge and skills to use and solve problems effectively with the technology. Literacy also involves a critical examination and understanding of the ethical and social issues related to the use of information and communications technology. When planning for instruction and assessment in Chemistry 11 and 12, teachers should provide opportunities for students to develop literacy in relation to information and communications technology sources, and to reflect critically on the role of these technologies in society.

Copyright and Responsibility

Copyright is the legal protection of literary, dramatic, artistic, and musical works; sound recordings; performances; and communications signals. Copyright provides creators with the legal right to be paid for their work and the right to say how their work is to be used. The law permits certain exceptions for schools (i.e., specific things permitted) but these are very limited, such as copying for private study or research. The copyright law determines how resources can be used in the classroom and by students at home.

In order to respect copyright it is necessary to understand the law. It is unlawful to do the following, unless permission has been given by a copyright owner:
- photocopy copyrighted material to avoid purchasing the original resource for any reason
- photocopy or perform copyrighted material beyond a very small part – in some cases the copyright law considers it "fair" to copy whole works, such as an article in a journal or a photograph, for purposes of research and private study, criticism, and review
- show recorded television or radio programs to students in the classroom unless these are cleared for copyright for educational use (there are exceptions such as for news and news commentary taped within one year of broadcast that by law have record-keeping requirements – see the web site at the end of this section for more details)
- photocopy print music, workbooks, instructional materials, instruction manuals, teacher guides, and commercially available tests and examinations
- show videorecordings at schools that are not cleared for public performance
- perform music or do performances of copyrighted material for entertainment (i.e., for purposes other than a specific educational objective)

- copy work from the Internet without an express message that the work can be copied

Permission from or on behalf of the copyright owner must be given in writing. Permission may also be given to copy or use all or some portion of copyrighted work through a licence or agreement. Many creators, publishers, and producers have formed groups or "collectives" to negotiate royalty payments and copying conditions for educational institutions. It is important to know what licences are in place and how these affect the activities schools are involved in. Some licences may also require royalty payments that are determined by the quantity of photocopying or the length of performances. In these cases, it is important to assess the educational value and merits of copying or performing certain works to protect the school's financial exposure (i.e., only copy or use that portion that is absolutely necessary to meet an educational objective).

It is important for education professionals, parents, and students to respect the value of original thinking and the importance of not plagiarizing the work of others. The works of others should not be used without their permission.

For more information about copyright, refer to www.cmec.ca/copyright/indexe.stm

Prescribed Learning Outcomes

Chemistry 11 and 12

Prescribed learning outcomes are content standards for the provincial education system; they are the prescribed curriculum. Clearly stated and expressed in measurable and observable terms, learning outcomes set out the required knowledge, skills, and attitudes – what students are expected to know and be able to do – by the end of the specified course.

Schools have the responsibility to ensure that all prescribed learning outcomes in this curriculum are met; however, schools have flexibility in determining how delivery of the curriculum can best take place.

It is expected that student achievement will vary in relation to the learning outcomes. Evaluation, reporting, and student placement with respect to these outcomes are dependent on the professional judgment and experience of teachers, guided by provincial policy.

Prescribed learning outcomes for Chemistry 11 and 12 are presented by grade and by curriculum organizer, and are coded alphanumerically for ease of reference; however, this arrangement is not intended to imply a required instructional sequence.

Wording of Prescribed Learning Outcomes

All learning outcomes complete the stem, "It is expected that students will…."

When used in a prescribed learning outcome, the word "**including**" indicates that any ensuing item **must be addressed**. Lists of items introduced by the word "including" represent a set of minimum requirements associated with the general requirement set out by the outcome. The lists are not necessarily exhaustive, however, and teachers may choose to address additional items that also fall under the general requirement set out by the outcome.

Domains of Learning

Prescribed learning outcomes in BC curricula identify required learning in relation to one or more of the three domains of learning: cognitive, psychomotor, and affective. The following definitions of the three domains are based on Bloom's taxonomy.

The **cognitive domain** deals with the recall or recognition of knowledge and the development of intellectual abilities. The cognitive domain can be further specified as including three cognitive levels: knowledge, understanding and application, and higher mental processes. These levels are determined by the verb used in the learning outcome, and illustrate how student learning develops over time.

- *Knowledge* includes those behaviours that emphasize the recognition or recall of ideas, material, or phenomena.
- *Understanding and application* represents a comprehension of the literal message contained in a communication, and the ability to apply an appropriate theory, principle, idea, or method to a new situation.
- *Higher mental processes* include analysis, synthesis, and evaluation. The higher mental processes level subsumes both the knowledge and the understanding and application levels.

The **affective domain** concerns attitudes, beliefs, and the spectrum of values and value systems.

The **psychomotor domain** includes those aspects of learning associated with movement and skill demonstration, and integrates the cognitive and affective consequences with physical performances.

Domains of learning and, particularly, cognitive levels, inform the design and development of the Graduation Program examination for Chemistry 12.

Prescribed Learning Outcomes: Chemistry 11

It is expected that students will:

Skills and Processes of Chemistry

A1 demonstrate appropriate safety techniques and proper use of protective equipment
A2 demonstrate skills in measuring and in recording data
A3 communicate results and data in clear and understandable forms

The Nature of Matter

B1 relate the observable properties and characteristics of elements, compounds, and mixtures to the concept of atoms and molecules
B2 write the names and formulae for ionic and covalent compounds, given appropriate charts or data tables
B3 describe the characteristics of matter
B4 differentiate between physical and chemical changes
B5 select an appropriate way of separating the components of a mixture

Mole Concept

C1 explain the significance and use of the mole
C2 perform calculations involving the mole
C3 determine relationships between molar quantities of gases at STP
C4 perform calculations involving molecular and empirical formulae to identify a substance
C5 describe concentration in terms of molarity
C6 perform calculations involving molarity

Chemical Reactions

D1 explain chemical reactions in terms of the rearrangement of the atoms as bonds are broken and new bonds are formed
D2 apply the law of conservation of mass to balance formula equations
D3 devise balanced equations for various chemical reactions
D4 describe reactions in terms of energy changes
D5 perform stoichiometric calculations involving chemical reactions

Prescribed Learning Outcomes: Chemistry 11	
Atomic Theory	
E1	describe the development of the model of the atom
E2	describe the sub-atomic structures of atoms, ions, and isotopes, using calculation where appropriate
E3	describe the development of the modern periodic table
E4	draw conclusions about the similarities and trends in the properties of elements, with reference to the periodic table
E5	justify chemical and physical properties in terms of electron population
E6	demonstrate knowledge of various types of chemical bonding
E7	apply understanding of bonding to create formulae and Lewis structures
Solution Chemistry	
F1	distinguish between a solution and a pure substance
F2	predict the relative solubility of a solute in a solvent, based on its polarity
F3	relate ion formation to electrical conductivity in aqueous solutions
F4	calculate the concentration of ions in solution
Organic Chemistry	
G1	describe characteristic features and common applications of organic chemistry
G2	demonstrate knowledge of the various ways that carbon and hydrogen can combine to form a wide range of compounds
G3	generate names and structures for simple organic compounds
G4	differentiate the various types of bonding between carbon atoms
G5	identify common functional groups
G6	perform a simple organic preparation

Prescribed Learning Outcomes: Chemistry 12

It is expected that students will:

Reaction Kinetics

A1 demonstrate awareness that reactions occur at differing rates
A2 experimentally determine rate of a reaction
A3 demonstrate knowledge of collision theory
A4 describe the energies associated with reactants becoming products
A5 apply collision theory to explain how reaction rates can be changed
A6 analyse the reaction mechanism for a reacting system
A7 represent graphically the energy changes associated with catalyzed and uncatalyzed reactions
A8 describe the uses of specific catalysts in a variety of situations

Dynamic Equilibrium

B1 explain the concept of chemical equilibrium with reference to reacting systems
B2 predict, with reference to entropy and enthalpy, whether reacting systems will reach equilibrium
B3 apply Le Châtelier's principle to the shifting of equilibrium
B4 apply the concept of equilibrium to a commercial or industrial process
B5 draw conclusions from the equilibrium constant expression
B6 perform calculations to evaluate the changes in the value of K_{eq} and in concentrations of substances within an equilibrium system

Solubility Equilibria

C1 determine the solubility of a compound in aqueous solution
C2 describe a saturated solution as an equilibrium system
C3 determine the concentration of ions in a solution
C4 determine the relative solubility of a substance, given solubility tables
C5 apply solubility rules to analyse the composition of solutions
C6 formulate equilibrium constant expressions for various saturated solutions
C7 perform calculations involving solubility equilibrium concepts
C8 devise a method for determining the concentration of a specific ion

Nature of Acid and Bases

D1 identify acids and bases through experimentation
D2 identify various models for representing acids and bases
D3 analyse balanced equations representing the reaction of acids or bases with water
D4 classify an acid or base in solution as either weak or strong, with reference to its electrical conductivity
D5 analyse the equilibria that exist in weak acid or weak base systems
D6 identify chemical species that are amphiprotic

Prescribed Learning Outcomes: Chemistry 12

Acids and Bases: Quantitative Problem Solving

E1 analyse the equilibrium that exists in water
E2 perform calculations relating pH, pOH, $[H_3O^+]$, and $[OH^-]$
E3 explain the significance of the K_a and K_b equilibrium expressions
E4 perform calculations involving K_a and K_b

Applications of Acid-Base Reactions

F1 demonstrate an ability to design, perform, and analyse a titration experiment involving the following:
- primary standards
- standardized solutions
- titration curves
- appropriate indicators

F2 describe an indicator as an equilibrium system
F3 perform and interpret calculations involving the pH in a solution and K_a for an indicator
F4 describe the hydrolysis of ions in salt solutions
F5 analyse the extent of hydrolysis in salt solutions
F6 describe buffers as equilibrium systems
F7 describe the preparation of buffer systems
F8 predict what will happen when oxides dissolve in rain water

Oxidation-Reduction

G1 describe oxidation and reduction processes
G2 analyse the relative strengths of reducing and oxidizing agents
G3 balance equations for redox reactions
G4 determine the concentration of a species by performing a redox titration

Applications of Redox Reactions

H1 analyse an electrochemical cell in terms of its components and their functions
H2 describe how electrochemical concepts can be used in various practical applications
H3 analyse the process of metal corrosion in electrochemical terms
H4 analyse an electrolytic cell in terms of its components and their functions
H5 describe how electrolytic concepts can be used in various practical applications

Student Achievement

Chemistry 11 and 12

This section of the IRP contains information about classroom assessment and student achievement, including specific achievement indicators to assist in the assessment of student achievement in relation to each prescribed learning outcome. Also included in this section are key elements – descriptions of content that help determine the intended depth and breadth of prescribed learning outcomes.

Classroom Assessment and Evaluation

Assessment is the systematic gathering of information about what students know, are able to do, and are working toward. Assessment evidence can be collected using a wide variety of methods, such as
- observation
- student self-assessments and peer assessments
- quizzes and tests (written, oral, practical)
- samples of student work
- projects and presentations
- oral and written reports
- journals and learning logs
- performance reviews
- portfolio assessments

Assessment of student performance is based on the information collected through assessment activities. Teachers use their insight, knowledge about learning, and experience with students, along with the specific criteria they establish, to make judgments about student performance in relation to prescribed learning outcomes.

Three major types of assessment can be used in conjunction to support student achievement.
- Assessment **for** learning is assessment for purposes of greater learning achievement.
- Assessment **as** learning is assessment as a process of developing and supporting students' active participation in their own learning.
- Assessment **of** learning is assessment for purposes of providing evidence of achievement for reporting.

Assessment for Learning

Classroom assessment for learning provides ways to engage and encourage students to become involved in their own day-to-day assessment – to acquire the skills of thoughtful self-assessment and to promote their own achievement.

This type of assessment serves to answer the following questions:
- What do students need to learn to be successful?
- What does the evidence of this learning look like?

Assessment for learning is criterion-referenced, in which a student's achievement is compared to established criteria rather than to the performance of other students. Criteria are based on prescribed learning outcomes, as well as on suggested achievement indicators or other learning expectations.

Students benefit most when assessment feedback is provided on a regular, ongoing basis. When assessment is seen as an opportunity to promote learning rather than as a final judgment, it shows students their strengths and suggests how they can develop further. Students can use this information to redirect their efforts, make plans, communicate with others (e.g., peers, teachers, parents) about their growth, and set future learning goals.

Assessment for learning also provides an opportunity for teachers to review what their students are learning and what areas need further attention. This information can be used to inform teaching and create a direct link between assessment and instruction. Using assessment as a way of obtaining feedback on instruction supports student achievement by informing teacher planning and classroom practice.

Assessment as Learning

Assessment as learning actively involves students in their own learning processes. With support and guidance from their teacher, students take responsibility for their own learning, constructing meaning for themselves. Through a process of continuous self-assessment, students develop the ability to take stock of what they have already learned, determine what they have not yet learned, and decide how they can best improve their own achievement.

Although assessment as learning is student-driven, teachers can play a key role in facilitating how this assessment takes place. By providing regular opportunities for reflection and self-assessment, teachers can help students develop, practise, and become comfortable with critical analysis of their own learning.

Assessment of Learning

Assessment of learning can be addressed through summative assessment, including large-scale assessments and teacher assessments. These summative assessments can occur at the end of the year or at periodic stages in the instructional process.

Large-scale assessments, such as Foundation Skills Assessment (FSA) and Graduation Program exams, gather information on student performance throughout the province and provide information for the development and revision of curriculum. These assessments are used to make judgments about students' achievement in relation to provincial and national standards. There is no large-scale provincial assessment for Chemistry 11. The large-scale provincial assessment for Chemistry 12 is the optional graduation program examination, worth 40% of the final course mark for students who choose to write it.

Assessment of learning is also used to inform formal reporting of student achievement.

For Ministry of Education reporting policy, refer to www.bced.gov.bc.ca/policy/policies/student_reporting.htm

Assessment *for* Learning	Assessment *as* Learning	Assessment *of* Learning
Formative assessment is *ongoing in the classroom*	**Formative assessment is *ongoing in the classroom***	**Summative assessment occurs *at end of year or at key stages***
• teacher assessment, student self-assessment, and/or student peer assessment • criterion-referenced – criteria based on prescribed learning outcomes identified in the provincial curriculum, reflecting performance in relation to a specific learning task • involves both teacher and student in a process of continual reflection and review about progress • teachers adjust their plans and engage in corrective teaching in response to formative assessment	• self-assessment • provides students with information on their own achievement and prompts them to consider how they can continue to improve their learning • student-determined criteria based on previous learning and personal learning goals • students use assessment information to make adaptations to their learning process and to develop new understandings	• teacher assessment • may be either criterion-referenced (based on prescribed learning outcomes) or norm-referenced (comparing student achievement to that of others) • information on student performance can be shared with parents/guardians, school and district staff, and other education professionals (e.g., for the purposes of curriculum development) • used to make judgments about students' performance in relation to provincial standards

For more information about assessment for, as, and of learning, refer to the following resource developed by the Western and Northern Canadian Protocol (WNCP): *Rethinking Assessment with Purpose in Mind.*

This resource is available online at www.wncp.ca/

Criterion-Referenced Assessment and Evaluation
In criterion-referenced evaluation, a student's performance is compared to established criteria rather than to the performance of other students. Evaluation in relation to prescribed curriculum requires that criteria be established based on the learning outcomes.

Criteria are the basis for evaluating student progress. They identify, in specific terms, the critical aspects of a performance or a product that indicate how well the student is meeting the prescribed learning outcomes. For example, weighted criteria, rating scales, or scoring guides (reference sets) are ways that student performance can be evaluated using criteria.

Wherever possible, students should be involved in setting the assessment criteria. This helps students develop an understanding of what high-quality work or performance looks like.

Criterion-referenced assessment and evaluation may involve these steps:	
Step 1	Identify the prescribed learning outcomes and suggested achievement indicators (as articulated in this IRP) that will be used as the basis for assessment.
Step 2	Establish criteria. When appropriate, involve students in establishing criteria.
Step 3	Plan learning activities that will help students gain the knowledge, skills, and attitudes outlined in the criteria.
Step 4	Prior to the learning activity, inform students of the criteria against which their work will be evaluated.
Step 5	Provide examples of the desired levels of performance.
Step 6	Conduct the learning activities.
Step 7	Use appropriate assessment instruments (e.g., rating scale, checklist, scoring guide) and methods (e.g., observation, collection, self-assessment) based on the particular assignment and student.
Step 8	Review the assessment data and evaluate each student's level of performance or quality of work in relation to criteria.
Step 9	Where appropriate, provide feedback and/or a letter grade to indicate how well the criteria are met.
Step 10	Communicate the results of the assessment and evaluation to students and parents/guardians.

Key Elements

Key elements provide an overview of content in each curriculum organizer. They can be used to determine the expected depth and breadth of the prescribed learning outcomes.

Achievement Indicators

To support the assessment of provincially prescribed curricula, this IRP includes sets of achievement indicators in relation to each learning outcome.

Achievement indicators, taken together as a set, define the specific level of knowledge acquired, skills applied, or attitudes demonstrated by the student in relation to a corresponding prescribed learning outcome. They describe what evidence to look for to determine whether or not the student has fully met the intent of the learning outcome. Since each achievement indicator defines only one aspect of the corresponding learning outcome, the entire set of achievement indicators should be considered when determining whether students have fully met the learning outcome.

In some cases, achievement indicators may also include suggestions as to the type of task that would provide evidence of having met the learning outcome (e.g., a constructed response such as a list, comparison, analysis, or chart; a product created and presented such as a report, drama presentation, poster, letter, or model; a particular skill demonstrated such as interpreting graphs).

Achievement indicators support the principles of assessment *for* learning, assessment *as* learning, and assessment *of* learning. They provide teachers and parents with tools that can be used to reflect on what students are learning, as well as provide students with a means of self-assessment and ways of defining how they can improve their own achievement.

Achievement indicators are not mandatory; they are suggestions only, provided to assist in the assessment of how well students achieve the prescribed learning outcomes.

Achievement indicators may be useful to provincial examination development teams and inform the development of exam items. However, examination questions, item formats, exemplars, rubrics, or scoring guides will not necessarily be limited to the achievement indicators as outlined in the Integrated Resource Packages.

> Specifications for provincial examinations are available online at www.bced.gov.bc.ca/exams/specs/

The following pages contain the suggested achievement indicators corresponding to each prescribed learning outcome for the Chemistry 11 and 12 curriculum. The achievement indicators are arranged by curriculum organizer and suborganizer for each grade; however, this order is not intended to imply a required sequence of instruction and assessment.

Student Achievement

Chemistry 11

Key Elements: Skills and Processes of Chemistry

Estimated Time: 5–6 hours

By the end of this course, students will be able to make observations in a safe and systematic manner and will collect and record data according to standard scientific technique, with special attention to significant figures and uncertainty.

Vocabulary

accuracy, analysis, interpretation, observation, precision, SI unit, significant figures, unit

Knowledge

- safety and protective equipment available in the laboratory
- common chemistry laboratory hazards
- SI units and their accepted alternatives in chemistry
- significant figures

Skills and Attitudes

- following safety procedures
- data manipulation when performing analyses and calculations
- distinguishing between observation and interpretation
- connecting objectives and conclusions
- interpreting tables
- observing, recording data from, and analysing chemical reactions

Skills and Processes of Chemistry

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
A1 demonstrate appropriate safety techniques and proper use of protective equipment	❑ identify the safety and protective equipment available in the laboratory and describe how and when to use each piece of equipment ❑ indicate on a school map the location of the nearest fire alarm and appropriate fire exits ❑ list sources of first-aid assistance other than the classroom teacher ❑ describe common chemistry laboratory hazards and the appropriate procedure or technique for dealing with each ❑ produce a list of general rules of safe laboratory conduct ❑ perform laboratory experiments in a safe manner
A2 demonstrate skills in measuring and in recording data	❑ use SI units and their accepted alternatives in chemistry ❑ recognize the imprecise nature of all measurements ❑ determine the number of significant figures in a measured quantity and relate to its uncertainty ❑ round off calculated results to the appropriate number of significant figures ❑ correctly determine the unit of a derived quantity (unit analysis)
A3 communicate results and data in clear and understandable forms	❑ produce lab reports in required formats ❑ draw appropriate connections between objectives and conclusions ❑ manipulate data correctly when performing analyses and calculations ❑ distinguish between observation and interpretation in the presentation of results

Key Elements: The Nature of Matter

Estimated Time: 9–13 hours

By the end of this course, students will be able to perform simple mixture separations and analyse data to distinguish and identify elements, compounds, and mixtures based on their chemical and physical properties.

Vocabulary

acid, atom, base, boiling point, chemical change, chemical property, chemical reactivity, chromatography, compound, distillation, element, evaporation, filtration, freezing point, gas, ion charge, ion/ionic, kinetic molecular theory, liquid, mass, matter, melting point, metal, mixture, molecular formula, molecule, monatomic ions, non-metal, physical change, physical property, pure substance, salt, solid

Knowledge

- characteristics of matter
- the naming system and correlation of chemical names and formulae
- physical and chemical changes of matter

Skills and Attitudes

- following safety procedures
- data manipulation when performing analyses and calculations
- distinguishing between observation and interpretation
- connecting objectives and conclusions
- interpreting tables (periodic table and table of common ions)
- classifying matter (elements into families; elements and compounds; pure substances and mixtures)
- naming compounds and writing formulae for compounds (organic and inorganic)
- separating components of a mixture (e.g., physical methods: chromatographic separation, distillation; chemical methods: reactivity with acids)
- observing, recording data from, and analysing chemical reactions

THE NATURE OF MATTER

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
B1 relate the observable properties and characteristics of elements, compounds, and mixtures to the concept of atoms and molecules	❑ classify a given material as an element, compound, or mixture, using the properties of the material ❑ describe a pure substance as having a set of unique and identifiable properties ❑ differentiate between atoms, molecules, and ions
B2 write the names and formulae for ionic and covalent compounds, given appropriate charts or data tables	❑ derive a chemical name, given a formula, periodic table, and table of common ions ❑ derive a formula (or symbol), given a chemical name, periodic table, and table of common ions ❑ name and write formulae for some common acids and bases ❑ use the prefix naming system for covalent compounds
B3 describe the characteristics of matter	❑ describe chemistry as the science concerned with the properties, composition, and behaviour of matter ❑ classify a substance as solid, liquid, or gas, and describe its different properties ❑ define the terms, matter, boiling point, freezing point, and melting point ❑ state the kinetic molecular theory ❑ describe the simple molecular motions and arrangements of particles in solids, liquids, and gases
B4 differentiate between physical and chemical changes	❑ describe the types of changes that may be observed when matter is heated, cooled, combined, or separated ❑ relate the heat changes that occur during phase changes to changes in molecular motions and arrangements
B5 select an appropriate way of separating the components of a mixture	❑ use various mechanical means to separate components of a mixture, including filtration, evaporation, chromatography, and distillation ❑ relate the method of separation to the properties of the mixture's components

Key Elements: Mole Concept

Estimated Time: 14–17 hours

By the end of this course, students will be able to relate the concept of the mole to the quantitative properties of matter.

Vocabulary

empirical formula, molarity, molar mass, molar solution, molar volume, mole, molecular formula, molecular mass, percentage composition, relative atomic mass, standard solution, stoichiometry, STP

Knowledge

- significance and use of the mole
- law of conservation of mass
- Avogadro's hypothesis

Skills and Attitudes

- following safety procedures
- data manipulation when performing analyses and calculations
- connecting objectives and conclusions
- interpreting tables (periodic table and table of common ions)
- naming compounds and writing formulae for compounds (organic and inorganic)
- performing calculations
  - involving moles, molarity, empirical and molecular formulae
  - involving stoichiometry
  - involving percent composition
- observing, recording data from, and analysing chemical reactions (e.g., formula of a hydrate, iron nail in copper (II) sulphate)

MOLE CONCEPT

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
C1 explain the significance and use of the mole	❑ recognize the significance of relative atomic mass, with reference to the periodic table ❑ identify the mole as the unit for counting atoms, molecules, or ions
C2 perform calculations involving the mole	❑ convert among the numbers of particles, moles, and mass ❑ determine the molar mass of an element or compound
C3 determine relationships between molar quantities of gases at STP	❑ define STP and state the molar volume of a gas at STP (i.e., 22.4 L/mol) ❑ determine experimentally the molar volume of a gas at room temperature and pressure ❑ calculate the moles or mass of a gas from a given volume at STP or vice versa
C4 perform calculations involving molecular and empirical formulae to identify a substance	❑ distinguish between empirical and molecular formulae ❑ determine the percent composition by mass from the formula of a compound ❑ determine the empirical formula for the compound from the percent composition by mass ❑ determine a molecular formula from the molecular mass and empirical formula
C5 describe concentration in terms of molarity	❑ express molarity using mol/L or M ❑ prepare a solution of known molarity (standard solution)
C6 perform calculations involving molarity	❑ perform calculations relating mass (or moles) of solute, volume of solution, and molarity ❑ calculate the resulting concentration when a given volume of a standard solution is diluted with water

Key Elements: Chemical Reactions

Estimated Time: 20–22 hours

By the end of this course, students will be able to explain changes to matter that occur in chemical reacting systems, use the mole ratio from balanced equations to calculate quantities of materials produced and consumed, and describe energy changes that occur during a physical or chemical change.

Vocabulary

acid-base neutralization, chemical reactivity, coefficients, combustion, decomposition, double replacement, endothermic, exothermic, formula equation, limiting reagent, precipitate, products, reactants, single replacement, stoichiometry, synthesis, thermochemical equation

Knowledge

- types of chemical reactions
- energy changes in reacting systems
- stoichiometry (percent composition, limiting and excess reactants)

Skills and Attitudes

- following safety procedures
- data manipulation when performing analyses and calculations
- connecting objectives and conclusions
- interpreting tables (periodic table and table of common ions)
- classifying types of compounds (e.g., carbonates, sulphates, acids, bases)
- naming compounds and writing formulae for compounds (organic and inorganic)
- performing calculations
  - involving moles, molarity, mass, and gas volumes at STP
  - involving stoichiometry (limiting and excess reactants)
- observing, recording data from, and analysing chemical reactions (synthesis, decomposition, single and double replacement, neutralization, combustion)
- balancing equations

CHEMICAL REACTIONS

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
D1 explain chemical reactions in terms of the rearrangement of the atoms as bonds are broken and new bonds are formed	❑ define reactants and products ❑ observe and record changes that occur during a chemical reaction
D2 apply the law of conservation of mass to balance formula equations	❑ gather experimental data that lead to the law of conservation of mass ❑ balance formula equations for chemical reactions ❑ use abbreviations (s, l, g, aq) to represent solids, liquids, gases, and aqueous solutions
D3 devise balanced equations for various chemical reactions	❑ classify, predict products, and write balanced equations for the following types of chemical reactions: – synthesis – decomposition – single replacement – double replacement – combustion – acid-base neutralization
D4 describe reactions in terms of energy changes	❑ define exothermic and endothermic reactions ❑ classify reactions as exothermic or endothermic based on experimental observations ❑ relate energy changes to bond breaking and forming ❑ write equations for chemical reactions including the energy term (thermochemical equations)
D5 perform stoichiometric calculations involving chemical reactions	❑ state Avogadro's hypothesis ❑ relate the coefficients in a balanced equation to the relative number of molecules or moles (the mole ratio) of reactants and products in the chemical reaction ❑ perform calculations involving reactions using any of the following: – number of molecules – moles – mass – gas volume at STP – solution concentration and volume (e.g., titration) ❑ perform calculations involving a limiting reagent

Key Elements: Atomic Theory

Estimated Time: 14–17 hours

By the end of this course, students will be able to relate the structure of the atom and the use of the periodic table to observed behaviours and trends in properties of various elements and will explain the significance of covalent and ionic bond types for simple compounds.

Vocabulary

alkali metals, alkaline earth metals, atom, atomic mass, atomic number, atomic radius, Bohr model, covalent bonding, electrical conductivity, electron, electron dot diagram, halogens, ionic bonding, ionization energy, isotope, Lewis structure, melting point, metal, metalloid, mole, neutron, noble gases, non-metal, particle charge, polarity, proton, relative atomic mass, transition metals, valence electrons

Knowledge

- atomic theory, structure, and periodicity
- electron arrangement for the first 20 elements (significance of spectral data)
- similarities and trends in the properties of elements
- types of chemical bonding
- the relationship between bonding, formulae, and Lewis structures

Skills and Attitudes

- interpreting tables (periodic table and table of common ions)
- classifying matter (isotopes, chemical families)
- observing (spectra of various elements)

ATOMIC THEORY

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
E1 describe the development of the model of the atom	❑ describe changes in the model of the atom as a result of the work of Dalton, Thomson, Rutherford, and Bohr
E2 describe the sub-atomic structures of atoms, ions, and isotopes, using calculation where appropriate	❑ describe the relative position, mass, and charge for a proton, neutron, and electron ❑ identify the atomic number of an element, using a table ❑ describe a simple electron arrangement for the first 20 elements ❑ define *isotope* ❑ calculate the number of neutrons, protons, and electrons for an atom or ion, given the mass number of the isotope and the charge of the ion ❑ calculate the average atomic mass from isotopic data
E3 describe the development of the modern periodic table	❑ explain the significance of the work of Mendeleev ❑ distinguish the ordering of elements in early periodic tables (based on atomic mass) from the ordering of elements in the modern periodic table (based on atomic number)
E4 draw conclusions about the similarities and trends in the properties of elements, with reference to the periodic table *Organizer 'Atomic Theory' continued on page 38*	❑ classify elements as metal, non-metal, or metalloid and locate them on the periodic table ❑ describe trends in properties such as melting point, ionization energy, atomic radius, chemical reactivity, ion charge, and conductivity ❑ identify the following families of elements: alkali metals, alkaline earth metals, halogens, noble gases, transition metals ❑ describe some properties of the alkali metals, alkaline earth metals, halogens, noble gases, and transition metals ❑ predict the characteristics of elements knowing the characteristics of another element in that family ❑ predict the formulae of compounds given the formula of another compound containing elements in the same families

Prescribed Learning Outcomes	Suggested Achievement Indicators
Organizer 'Atomic Theory' *continued from page 37*	
E5 justify chemical and physical properties in terms of electron population	❑ relate noble gas stability to electron arrangement within the atom ❑ predict the probable electron gain or loss for elements in columns 1, 2, 13, 15, 16, and 17 ❑ relate the observed charge of monatomic ions of metals and non-metals to numbers of electrons lost or gained
E6 demonstrate knowledge of various types of chemical bonding	❑ define *covalent* and *ionic bonding* ❑ define *valence electrons* ❑ recognize the connection between bonding and valence electrons
E7 apply understanding of bonding to create formulae and Lewis structures	❑ identify from a chemical formula the probable type of bond (ionic or covalent) ❑ draw an electron dot diagram (Lewis structures) for an atom, ion, or molecule ❑ draw structural formulae for simple molecules and ions, and deduce molecular formulae

Key Elements: Solution Chemistry

Estimated Time: 14–17 hours

By the end of this course, students will be able to demonstrate and explain solution formation, solubility, and the interactions between solute and solvent.

Vocabulary

acid-base neutralization, dissociation equation, electrical conductivity, ion charge, ionization equation, molarity, molar solution, mole, non-polar, polar, solute, solvent, solution

Knowledge

- the difference between pure substances and solutions
- electrical conductivity in aqueous solutions
- nature of solutes and solvents (polar and non-polar)

Skills and Attitudes

- following safety procedures
- interpreting tables (periodic table and table of common ions)
- classifying solutes and solvents (polar and non-polar)
- performing calculations
  - involving moles and molarity
  - involving stoichiometry
  - determining the concentration of ions in solution
- observing, recording data from, and analysing solute-solvent interactions (e.g., sugar, salt, or iodine in water vs. paint thinner)
- balancing ionic equations

SOLUTION CHEMISTRY

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
F1 distinguish between a solution and a pure substance	❑ define *solution* as a homogeneous mixture comprised of a solute and solvent ❑ give examples of solid, liquid, or gaseous solutions
F2 predict the relative solubility of a solute in a solvent, based on its polarity	❑ categorize various common solvents as polar and non-polar ❑ on the basis of lab observations, make deductions concerning the solubility of ionic, polar, and non-polar solutes in polar and non-polar solvents
F3 relate ion formation to electrical conductivity in aqueous solutions	❑ use lab observations to describe the relative conductivity of several solutes in aqueous solution ❑ summarize the results of a conductivity experiment as to the types of solute that conduct electricity when dissolved in water ❑ write dissociation or ionization equations for several substances that dissolve in water to give conducting solutions
F4 calculate the concentration of ions in solution	❑ calculate the molarity of each ion in a salt solution given the molarity of the solution ❑ calculate the concentration of ions resulting when two solutions of known concentration and volume are mixed (assuming no reaction)

Key Elements: Organic Chemistry

Estimated Time: 14–18 hours

By the end of this course, students will be able to demonstrate an awareness of the variety and complexity of organic chemical systems, with specific reference to various functional groups.

Vocabulary

alcohol, aldehyde, alkane, alkene, alkyne, amide, amine, aromatic, benzene ring, bromo-, chloro-, cyclic, ester, ether, ethyl-, fluoro-, hydrocarbon, ketone, methyl-, organic acid, organic chemistry, substituent groups

Knowledge

- nature, features, and uses of organic chemistry
- the various ways that carbon and hydrogen can combine (including carbon-carbon bonding)
- names and structures of alkanes, alkenes, and alkynes up to C_{10} and of substituent groups (methyl, ethyl, fluoro, chloro, bromo, and iodo)
- common functional groups

Skills and Attitudes

- following safety procedures
- connecting objectives and conclusions
- classifying compounds (functional groups)
- naming compounds and writing formulae for organic compounds
- balancing equations
- performing simple organic preparations (e.g., ester preparation lab)

ORGANIC CHEMISTRY

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
G1 describe characteristic features and common applications of organic chemistry	❑ identify carbon as the "backbone" of organic chemistry ❑ identify the multiple bonding character of carbon atoms ❑ relate organic chemistry to products such as plastics, fuels, pharmaceutical drugs, pesticides, insecticides, solvents, and synthetics ❑ identify major sources of organic compounds
G2 demonstrate knowledge of the various ways that carbon and hydrogen can combine to form a wide range of compounds	❑ define *hydrocarbon*, *alkane*, *alkene*, *alkyne*, *cyclic*, and *aromatic* as they relate to organic compounds ❑ classify a hydrocarbon as either saturated or unsaturated ❑ compare the geometry of single, double, and triple bonds between two carbon atoms ❑ draw the structure of a benzene ring
G3 generate names and structures for simple organic compounds	❑ name and draw structures of alkanes, alkenes, and alkynes up to C_{10} ❑ recognize and name the substituent groups methyl, ethyl, fluoro, chloro, bromo, and iodo ❑ name and draw structures of simple substituted alkanes to C_{10}
G4 differentiate the various types of bonding between carbon atoms	❑ compare the rotational ability in single, double, and triple bonds ❑ consistently identify cis- or trans- isomers of alkenes ❑ name and draw structures for simple alcohols
G5 identify common functional groups	❑ define the term *functional group* ❑ identify a compound as an alcohol, aldehyde, ketone, ether, organic acid, ester, amine, or amide when given a structural diagram
G6 perform a simple organic preparation	❑ demonstrate how an ester can be prepared through the reaction of an alcohol and an organic acid and how it can be detected (by its aroma)

Student Achievement

Chemistry 12

Key Elements: Reaction Kinetics

Estimated Time: 14–16 hours

By the end of this course, students will be able to explain the significance of reaction rates, demonstrate how rates can be measured and explain, with reference to Collision Theory and reaction mechanisms, how rates are altered.

Vocabulary

activated complex, activation energy, catalyst, collision theory, ΔH notation, endothermic, enthalpy, exothermic, KE distribution curve, kinetic energy (KE), potential energy (PE), product, rate-determining step, reactant, reaction intermediate, reaction mechanism, reaction rate, successful collision, thermochemical equation

Knowledge

- reaction rates
- collision theory (significance with respect to reaction rates)
- factors affecting reaction rates
- reaction mechanisms (including role and applications of catalysts)

Skills and Attitudes

- calculating reaction rates from experimental data (e.g., bleach decomposition, zinc in hydrochloric acid, iodine clock reaction)
- analysing reaction mechanisms
- graphically representing energy changes in reactions

REACTION KINETICS

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
A1 demonstrate awareness that reactions occur at differing rates	❑ give examples of reactions proceeding at different rates ❑ recognize that rate is described in terms of some quantity (produced or consumed) per unit of time
A2 experimentally determine rate of a reaction	❑ identify properties that could be monitored in order to determine a reaction rate ❑ recognize some of the factors that control reaction rates ❑ compare and contrast factors affecting the rates of both homogeneous and heterogeneous reactions ❑ describe situations in which the rate of reaction must be controlled ❑ calculate the rate of a reaction using experimental data
A3 demonstrate knowledge of collision theory	❑ identify the following principles as aspects of collision theory: – reactions are the result of collisions between reactant particles – not all collisions are successful – sufficient kinetic energy (KE) and favourable geometry are required – to increase the rate of a reaction, one must increase the frequency of successful collisions – energy changes are involved in reactions as bonds are broken and formed – a KE distribution curve can explain how changing temperature or adding a catalyst changes the rate
A4 describe the energies associated with reactants becoming products *Organizer 'Reaction Kinetics' continued on page 46*	❑ describe the activated complex in terms of its potential energy (PE), stability, and structure ❑ define *activation energy* ❑ correctly describe the relationship between activation energy and rate of reaction ❑ describe the changes in KE and PE as reactant molecules approach each other ❑ draw and label PE diagrams for both exothermic and endothermic reactions, including ΔH, activation energy, and the energy of the activated complex ❑ relate the sign of ΔH to whether the reaction is exothermic or endothermic ❑ write chemical equations that describe energy effects in two ways: – a chemical equation that includes the energy term (thermochemical equation) – a chemical equation using ΔH notation

Prescribed Learning Outcomes	Suggested Achievement Indicators
Organizer 'Reaction Kinetics' continued from page 45	
A5 apply collision theory to explain how reaction rates can be changed	❑ use collision theory to explain the effect of the following factors on reaction rate: – nature of reactants – concentration – temperature – surface area
A6 analyse the reaction mechanism for a reacting system	❑ explain why most reactions involve more than one step ❑ describe a reaction mechanism as the series of steps (collisions) that result in the overall reaction and describe the role of the rate-determining step ❑ explain the significance and role of a catalyst ❑ identify reactant, product, reaction intermediate, activated complex, and catalyst from a given reaction mechanism
A7 represent graphically the energy changes associated with catalyzed and uncatalyzed reactions	❑ compare the PE diagrams for a catalyzed and uncatalyzed reaction in terms of – reactants – products – activated complex – reaction intermediates – reaction mechanism – ΔH – activation energy
A8 describe the uses of specific catalysts in a variety of situations	❑ identify platinum in automobile catalytic converters as a catalyst ❑ describe the effect of a catalyst on a number of reactions, such as – decomposition of hydrogen peroxide (catalysts: manganese (IV) oxide, raw liver, raw potato) – the reaction of the oxalate ion with acidified potassium permanganate solution (catalyst: Mn^{2+}) – the decomposition of bleach (catalyst: cobalt (II) chloride)

Key Elements: Dynamic Equilibrium

Estimated Time: 14–16 hours

By the end of this course, students will be able to analyse reversible reacting systems, with reference to equilibrium systems, Le Châtelier's Principle, and the concept of a reaction constant, K_{eq}.

Vocabulary

chemical equilibrium, closed system, dynamic equilibrium, enthalpy, entropy, equilibrium concentration, equilibrium constant expression, equilibrium shift, Haber process, heterogeneous reaction, homogeneous reaction, K_{eq}, Le Châtelier's principle, macroscopic properties, open system, PE diagram

Knowledge

- characteristics of chemical equilibrium
- requirements for chemical equilibrium
- Le Châtelier's principle (dynamic equilibrium and equilibrium shifts – significance and application)

Skills and Attitudes

- predicting effect on equilibrium when changes are made (e.g., chromate-dichromate, iron (III) thiocyanide equilibria)
- performing calculations involving K_{eq}, initial concentrations, and equilibrium concentration

Dynamic Equilibrium

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
B1 explain the concept of chemical equilibrium with reference to reacting systems	❑ describe the reversible nature of most chemical reactions and how it can be represented on a PE diagram ❑ describe the dynamic nature of chemical equilibrium ❑ relate the changes in rates of the forward and reverse reactions to the changing concentrations of the reactants and products as equilibrium is established ❑ describe chemical equilibrium as a closed system at constant temperature: – whose macroscopic properties are constant – where the forward and reverse reaction rates are equal – that can be achieved from either direction – where the concentrations of reactants and products are constant ❑ infer that a system not at equilibrium will tend to move toward a position of equilibrium
B2 predict, with reference to entropy and enthalpy, whether reacting systems will reach equilibrium	❑ explain the significance of enthalpy and entropy ❑ determine entropy and enthalpy changes from a chemical equation (qualitatively) ❑ predict the result when enthalpy and entropy factors – both favour the products – both favour the reactants – oppose one another
B3 apply Le Châtelier's principle to the shifting of equilibrium	❑ explain the term shift as it applies to equilibria ❑ describe shifts resulting from the following: – temperature change – concentration change – volume change of gaseous systems ❑ explain equilibrium shifts using the concepts of reaction kinetics ❑ identify the effect of a catalyst on dynamic equilibrium
B4 apply the concept of equilibrium to a commercial or industrial process *Organizer 'Dynamc Equilibrium' continued on page 49*	❑ describe the Haber process for the production of ammonia (NH_3)

Prescribed Learning Outcomes	Suggested Achievement Indicators
Organizer 'Dynamic Equilibrium' continued from page 48	
B5 draw conclusions from the equilibrium constant expression	❑ gather and interpret data on the concentration of reactants and products of a system at equilibrium ❑ write the expression for the equilibrium constant when given the equation for either a homogeneous or heterogeneous equilibrium system ❑ explain why certain terms (i.e., pure solids and liquids) are not included in the equilibrium constant expression ❑ relate the equilibrium position to the value of K_{eq} and vice versa ❑ predict the effect (or lack of effect) on the value of K_{eq} of changes in the following factors: temperature, pressure, concentration, surface area, and catalyst
B6 perform calculations to evaluate the changes in the value of K_{eq} and in concentrations of substances within an equilibrium system	❑ perform calculations involving the value of K_{eq} and the equilibrium concentration of all species ❑ perform calculations involving the value of K_{eq}, the initial concentrations of all species, and one equilibrium concentration ❑ perform calculations involving the equilibrium concentrations of all species, the value of K_{eq}, and the initial concentrations ❑ determine whether a system is at equilibrium, and if not, in which direction it will shift to reach equilibrium when given a set of concentrations for reactants and products

Key Elements: Solubility Equilibria

Estimated Time: 14–16 hours

By the end of this course, students will be able to demonstrate and explain solute-solvent interactions in solubility equilibria and describe the significance of K_{sp} with respect to saturated systems.

Vocabulary

aqueous solution, common ion, complete ionic equation, dissociation equation, electrical conductivity, formula equation, hard water, ionic solution, K_{sp}, molecular solution, net ionic equation, precipitate, relative solubility, saturated solution, solubility equilibrium

Knowledge

- ionic vs. molecular solutions
- relative solubility of solutes
- solubility rules
- equilibrium in saturated solutions

Skills and Attitudes

- distinguishing between ionic and molecular solutions (e.g., electrical conductivity)
- determining the composition of solutions and the concentration of an ion in a given solution
- performing calculations involving solubility equilibrium concepts

Solubility Equilibria

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
C1 determine the solubility of a compound in aqueous solution	❑ classify a solution as ionic or molecular, given its conductivity or the formula of the solute ❑ describe the conditions necessary to form a saturated solution ❑ describe solubility as the concentration of a substance in a saturated solution ❑ use appropriate units to represent the solubility of substances in aqueous solutions
C2 describe a saturated solution as an equilibrium system	❑ describe the equilibrium that exists in a saturated aqueous solution ❑ describe a saturated solution using a net ionic equation
C3 determine the concentration of ions in a solution	❑ write dissociation equations ❑ calculate the concentration of the positive and negative ions given the concentration of a solute in an aqueous solution
C4 determine the relative solubility of a substance, given solubility tables *Organizer 'Solubility Equilibria' continued on page 52*	❑ describe a compound as having high or low solubility relative to 0.1 M by using a solubility chart ❑ use a solubility chart to predict if a precipitate will form when two solutions are mixed, and identify the precipitate ❑ write a formula equation, complete ionic equation, and net ionic equation that represent a precipitation reaction

Prescribed Learning Outcomes	Suggested Achievement Indicators
Organizer 'Solubility Equilibria' continued from page 51	
C5 apply solubility rules to analyse the composition of solutions	❑ use a solubility chart to predict if ions can be separated from solution through precipitation, and outline an experimental procedure that includes – compound added – precipitate formed – method of separation ❑ predict qualitative changes in the solubility equilibrium upon the addition of a common ion or the removal of an ion ❑ identify an unknown ion through experimentation involving a qualitative analysis scheme ❑ devise a procedure by which the calcium and/or magnesium ions can be removed from hard water
C6 formulate equilibrium constant expressions for various saturated solutions	❑ describe the K_{sp} expression as a specialized K_{eq} expression ❑ write a K_{sp} expression for a solubility equilibrium
C7 perform calculations involving solubility equilibrium concepts	❑ calculate the K_{sp} for a compound when given its solubility (e.g., $AgCl$, Ag_2S, $PbCl_2$) ❑ calculate the solubility of a compound from its K_{sp} ❑ predict the formation of a precipitate by comparing the trial ion product to the K_{sp} value using specific data ❑ calculate the maximum allowable concentration of one ion given the K_{sp} and the concentration of the other ion just before precipitation occurs
C8 devise a method for determining the concentration of a specific ion	❑ determine the concentration of chloride ion (by titration or gravimetric methods) using a precipitation reaction with silver ion

Key Elements: Nature of Acids and Bases

Estimated Time: 7–10 hours

By the end of this course, students will be able to describe the specific characteristics of acids and bases and distinguish the varying strengths of acids or bases for equilibria using a Brönsted-Lowry model.

Vocabulary

acid, amphiprotic, Arrhenius, base, Brönsted-Lowry, conjugate acid-base pair, electrical conductivity, strong acid, strong base, weak acid, weak base

Knowledge

- names, properties, and formulae of acids and bases
- models for representing acids and bases
- weak and strong acids and bases

Skills and Attitudes

- identifying acids or bases experimentally (e.g., common household acids and bases with litmus paper)
- writing balanced equations involving acids or bases
- analysing weak-acid and weak-base equilibria

NATURE OF ACIDS AND BASES

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
D1 identify acids and bases through experimentation	❑ list general properties of acids and bases ❑ write names and formulae of some common household acids and bases ❑ write balanced equations representing the neutralization of acids by bases in solution ❑ outline some of the uses and commercial names of common household acids and bases
D2 identify various models for representing acids and bases	❑ define *Arrhenius acids* and *bases* ❑ define *Brönsted-Lowry acids* and *bases*
D3 analyse balanced equations representing the reaction of acids or bases with water	❑ identify Brönsted-Lowry acids and bases in an equation ❑ define *conjugate acid-base pair* ❑ identify the conjugate of a given acid or base ❑ show that in any Brönsted-Lowry acid-base equation there are two conjugate pairs present ❑ identify an H_3O^+ ion as a protonated H_2O molecule that can be represented in shortened form as H^+
D4 classify an acid or base in solution as either weak or strong, with reference to its electrical conductivity	❑ relate electrical conductivity in a solution to the total concentration of ions in the solution ❑ define and give several examples for the following terms: – strong acid – strong base – weak acid – weak base ❑ write equations to show what happens when strong and weak acids and bases are dissolved in water
D5 analyse the equilibria that exist in weak acid or weak base systems	❑ compare the relative strengths of acids or bases by using a table of relative acid strengths ❑ predict whether products or reactants are favoured in an acid-base equilibrium by comparing the strength of the two acids (or two bases) ❑ compare the relative concentrations of H_3O^+ (or OH^-) between two acids (or between two bases) using their relative positions on an acid strength table
D6 identify chemical species that are amphiprotic	❑ define *amphiprotic* ❑ describe situations in which H_2O would act as an acid or base

Key Elements: Acids and Bases: Quantitative Problem Solving

Estimated Time: 8–12 hours

By the end of this course, students will be able to describe the special role played by water in aqueous systems and use the acid-base equilibrium constants (K_a and K_b) and the ionization constant of water (K_w) to calculate pH and pOH values for different acid-base equilibria.

Vocabulary

acid ionization constant (K_a), base ionization constant (K_b), ion product constant, pH, pK_w, pOH, water ionization constant (K_w)

Knowledge

- the pH/pOH scale
- acid and base ionization constants
- water ionization constant
- the K_a table

Skills and Attitudes

- analysing weak-acid and weak-base equilibria using the K_a table
- performing calculations
  - involving K_a and K_b
  - relating pH, pOH, [H_3O^+], and [OH^-]

ACIDS AND BASES: QUANTITATIVE PROBLEM SOLVING

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
E1 analyse the equilibrium that exists in water	❑ write equations representing the ionization of water using either H_3O^+ and OH^- or H^+ and OH^- ❑ predict the effect of the addition of an acid or base to the equilibrium system: $2H_2O \leftrightarrows H_3O^+ + OH^-$ ❑ state the relative concentrations of H_3O^+ and OH^- in acid, base, and neutral solutions ❑ write the equilibrium expression for the ion product constant of water (water ionization constant: K_w) ❑ state the value of K_w at 25°C ❑ describe and explain the variation in the value of K_w with temperature ❑ calculate the concentration of H_3O^+ (or OH^-) given the other, using K_w
E2 perform calculations relating pH, pOH, $[H_3O^+]$, and $[OH^-]$	❑ define pH and pOH ❑ define pK_w , give its value at 25°C, and its relation to pH and pOH ❑ calculate $[H_3O^+]$ or $[OH^-]$ from pH and pOH ❑ describe the pH scale with reference to everyday solutions
E3 explain the significance of the K_a and K_b equilibrium expressions	❑ write K_a and K_b equilibrium expressions for weak acids or weak bases ❑ relate the magnitude of K_a (the acid ionization constant) or K_b (the base ionization constant) to the strength of the acid or base
E4 perform calculations involving K_a and K_b	❑ given the K_a, K_b, and initial concentration, calculate any of the following: – $[H_3O^+]$ – $[OH^-]$ – pH – pOH ❑ calculate the value of K_b for a base given the value of K_a for its conjugate acid (or vice versa) ❑ calculate the value of K_a or K_b given the pH and initial concentration ❑ calculate the initial concentration of an acid or base, given the appropriate K_a, K_b, pH, or pOH values

Key Elements: Applications of Acid-Base Reactions

Estimated Time: 11–14 hours

By the end of this course, students will be able to identify practical applications of acid-base systems, demonstrate the use of titrations to determine quantities of materials, explain the significance of hydrolysis, and relate buffer systems and acid rain to the concept of acid-base equilibrium.

Vocabulary

acid rain, buffers, dissociation equation, equivalence point (stoichiometric point), hydrolysis, hydrolysis reaction, indicator, primary standards, salt, titration, titration curve, transition point

Knowledge

- significance and use of indicators
- hydrolysis of ions in salt solutions
- buffer systems (characteristics, significance, applications)
- acid rain (nature, causes, significance)

Skills and Attitudes

- performing calculations
  - involving K_a and K_b
  - relating pH, pOH, $[H_3O^+]$, and $[OH^-]$
  - involving the pH in a solution and K_a for an indicator
- designing, performing, and analysing a titration experiment (e.g., acid-base titration)

APPLICATIONS OF ACID-BASE REACTIONS

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
F1 demonstrate an ability to design, perform, and analyse a titration experiment involving the following: – primary standards – standardized solutions – titration curves – appropriate indicators	❑ write formulae, complete ionic equations, and net ionic equations for – a strong acid reacting with a strong base (neutralization) – a weak acid reacting with a strong base – a strong acid reacting with a weak base ❑ demonstrate proper titration technique when performing a titration experiment ❑ explain the difference between the equivalence point (stoichiometric point) of a strong acid-strong base titration and the equivalence point of a titration involving a weak acid-strong base or strong acid-weak base ❑ interpret titration curves plotted from experimental data ❑ select indicators whose transition point coincides with the equivalence point of the titration reaction ❑ calculate the concentration of an acid or base using titration data or similar data (e.g., grams or moles) ❑ calculate the volume of an acid or base of known molarity needed to completely react with a given amount of base or acid ❑ calculate the pH of a solution formed when a strong acid is mixed with a strong base
F2 describe an indicator as an equilibrium system	❑ describe an indicator as a mixture of a weak acid and its conjugate base, each with distinguishing colours ❑ describe the term transition point of an indicator, including the conditions that exist in the equilibrium system ❑ describe the shift in equilibrium and resulting colour changes as an acid or a base is added to an indicator
F3 perform and interpret calculations involving the pH in a solution and K_a for an indicator *Organizer 'Applications of Acid-Base Reactions' continued on page 59*	❑ predict the approximate pH at the transition point using the K_a value of an indicator ❑ predict the approximate K_a value for an indicator given the approximate pH range of the colour change ❑ match an indicator's colour in a solution with an approximate pH, using a table of indicators

Prescribed Learning Outcomes	Suggested Achievement Indicators
Organizer 'Applications of Acid-Base Reactions' continued from page 58	
F4 describe the hydrolysis of ions in salt solutions	❑ write a dissociation equation for a salt in water ❑ write net ionic equations representing the hydrolysis of ions in solution
F5 analyse the extent of hydrolysis in salt solutions	❑ predict whether a salt solution would be acidic, basic, or neutral (compare K_a and K_b values, where necessary) ❑ determine whether an amphiprotic ion will act as a base or an acid in solution (compare K_a and K_b values, where necessary) ❑ calculate the pH of a salt solution from relevant data, assuming that the predominant hydrolysis reaction is the only reaction determining the pH
F6 describe buffers as equilibrium systems	❑ describe the tendency of buffer solutions to resist changes in pH (i.e., able to buffer the addition of small amounts of strong acid or the addition of small amounts of strong base) ❑ describe the composition of an acidic buffer and a basic buffer ❑ describe qualitatively how the buffer equilibrium shifts as small quantities of acid or base are added to the buffer; the stress being the change in the concentration of the stronger acid (H_3O^+) or base (OH^-) ❑ describe in detail a common buffer system (e.g., the blood buffer system)
F7 describe the preparation of buffer systems	❑ outline a procedure to prepare a buffer solution ❑ identify the limitations in buffering action
F8 predict what will happen when oxides dissolve in rain water	❑ write equations representing the formation of acidic solutions or basic solutions from non-metal and metal oxides ❑ describe the pH conditions required for rain to be called acid rain (pH 5.0 and lower) ❑ relate the pH of normal rain water to the presence of dissolved CO_2 (approximately pH 5.6) ❑ describe sources of NO_x (automobile engines) and SO_x (fuels containing sulfur and smelters of sulfide ores) ❑ discuss general environmental problems associated with acid rain

Key Elements: Oxidation-Reduction

Estimated Time: 12–13 hours

By the end of this course, students will be able to describe the essential components of reacting systems that involve electron transfer, determine the stoichiometry of redox reactions by balancing redox reactions, and apply their findings to perform redox titrations.

Vocabulary

half-reaction, oxidation, oxidation number, oxidizing agent, redox reaction, redox titration, reducing agent, reduction

Knowledge

- vocabulary of redox reactions
- characteristics of redox reactions
- "Standard Reduction Potentials of Half-Cells" table

Skills and Attitudes

- recognizing redox reactions
- assigning oxidation numbers
- creating a simple table of reduction half-reactions
- predicting the spontaneity of reactions
- analysing the relative strengths of reducing and oxidizing agents
- balancing redox equations
- perform a redox titration (e.g., the iron (II) ion with the permanganate ion)

OXIDATION-REDUCTION

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
G1 describe oxidation and reduction processes	❑ define and identify – oxidation – reduction – oxidizing agent – reducing agent – half-reaction – redox reaction ❑ determine the following: – the oxidation number of an atom in a chemical species – the change in oxidation number an atom undergoes when it is oxidized or reduced – whether an atom has been oxidized or reduced by its change in oxidation number ❑ relate change in oxidation number to gain or loss of electrons
G2 analyse the relative strengths of reducing and oxidizing agents	❑ from data for a series of simple redox reactions, create a simple table of reduction half-reactions ❑ identify the relative strengths of oxidizing and reducing agents from their positions on a half-reaction table ❑ use the “Standard Reduction Potentials of Half-Cells” table to predict whether a spontaneous redox reaction will occur between any two species
G3 balance equations for redox reactions	❑ balance the equation for – a half-reaction in solutions that are acidic, basic, or neutral – a net ionic redox reaction in acidic or basic solution ❑ write the equations for reduction and oxidation half-reactions, given a redox reaction ❑ identify reactants and products for various redox reactions performed in a laboratory, and write balanced equations
G4 determine the concentration of a species by performing a redox titration	❑ demonstrate familiarity with at least two common reagents used in redox titrations (e.g., permanganate, dichromate, hydrogen peroxide) ❑ select a suitable reagent to be used in a redox titration, in order to determine the concentration of a species ❑ calculate the concentration of a species in a redox titration from data (e.g., grams, moles, molarity)

Key Elements: Applications of Redox Reactions

Estimated Time: 10–13 hours

By the end of this course, students will be able to use the concept of spontaneous and non-spontaneous reactions to explain practical applications of redox such as batteries, electroplating, electrorefining, and corrosion.

Vocabulary

cathodic protection, corrosion, electrochemical cell, electrode, electrolysis, electrolytic cell, electroplating, electrorefining, half-cell

Knowledge

- electrochemical cells: parts, voltages (E^0), half-reactions involved, practical applications
- common electrochemical cells (e.g., lead-acid battery, fuel cell, alkaline cell)
- electrolytic cells: parts, voltages required, half-reactions involved, practical applications
- metal corrosion as a chemical process (causes, prevention)

Skills and Attitudes

- designing and building electrochemical and electrolytic cells
- predicting ion flow and calculating voltages in electrochemical and electrolytic cells

Applications of Redox Reactions

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
H1 analyse an electrochemical cell in terms of its components and their functions	❑ construct an electrochemical cell ❑ define and label the parts of an electrochemical cell ❑ determine the half-reactions that take place at each electrode of an electrochemical cell, and use these to make predictions about the overall reaction and about – the direction of movement of each type of ion in the cell – the direction of flow of electrons in an external circuit – what will happen to the mass of each electrode as the cell operates ❑ predict the cell potential when equilibrium is reached ❑ determine voltages of half-reactions by analysing the voltages of several cells, with reference to the standard hydrogen half-cell ❑ identify the standard conditions for E^0 values ❑ predict the voltage (E^0) of an electrochemical cell using the "Standard Reduction Potentials of Half-Cells" table ❑ predict the spontaneity of the forward or reverse reaction from the E^0 of a redox reaction
H2 describe how electrochemical concepts can be used in various practical applications	❑ give examples of applications of electrochemical cells, including lead-acid storage batteries, alkali cells, and hydrogen-oxygen fuel cells, and explain how each functions
H3 analyse the process of metal corrosion in electrochemical terms	❑ describe the conditions necessary for corrosion of metals to occur ❑ suggest several methods of preventing or inhibiting corrosion of a metal, including cathodic protection, and account for the efficacy of each method
H4 analyse an electrolytic cell in terms of its components and their functions	❑ define *electrolysis* and *electrolytic cell* ❑ design and label the parts of an electrolytic cell used for the electrolysis of a molten binary salt such as NaCl liquid ❑ design and label the parts of an electrolytic cell capable of electrolyzing an aqueous salt such as KI aqueous (use of overpotential effect not required) ❑ predict the direction of flow of all ions in the cell and electrons in the external circuit ❑ write the half-reaction occurring at each electrode and predict observations based on this information ❑ write the overall cell reaction and predict the minimum voltage required for it to operate under standard conditions
H5 describe how electrolytic concepts can be used in various practical applications	❑ explain the principles involved in simple electroplating ❑ design and label an electrolytic cell capable of electroplating an object ❑ demonstrate familiarity with electrolytic cells in metal refining processes, including refining of zinc and aluminum

Learning Resources

Chemistry 11 and 12

This section contains general information on learning resources, and provides a link to the titles, descriptions, and ordering information for the recommended learning resources in the Chemistry 11 and 12 Grade Collections.

What Are Recommended Learning Resources?
Recommended learning resources are resources that have undergone a provincial evaluation process using teacher evaluators and have Minister's Order granting them provincial recommended status. These resources may include print, video, software and CD-ROMs, games and manipulatives, and other multimedia formats. They are generally materials suitable for student use, but may also include information aimed primarily at teachers.

Information about the recommended resources is organized in the format of a Grade Collection. A Grade Collection can be regarded as a "starter set" of basic resources to deliver the curriculum. In many cases, the Grade Collection provides a choice of more than one resource to support curriculum organizers, enabling teachers to select resources that best suit different teaching and learning styles. Teachers may also wish to supplement Grade Collection resources with locally approved materials.

How Can Teachers Choose Learning Resources to Meet Their Classroom Needs?
Teachers must use either:
- provincially recommended resources OR
- resources that have been evaluated through a local, board-approved process

Prior to selecting and purchasing new learning resources, an inventory of resources that are already available should be established through consultation with the school and district resource centres. The ministry also works with school districts to negotiate cost-effective access to various learning resources.

What Are the Criteria Used to Evaluate Learning Resources?
The Ministry of Education facilitates the evaluation of learning resources that support BC curricula, and that will be used by teachers and/or students for instructional and assessment purposes. Evaluation criteria focus on content, instructional design, technical considerations, and social considerations.

Additional information concerning the review and selection of learning resources is available from the ministry publication, *Evaluating, Selecting and Managing Learning Resources: A Guide* (Revised 2002)
www.bced.gov.bc.ca/irp/resdocs/esm_guide.pdf

What Funding is Available for Purchasing Learning Resources?
As part of the selection process, teachers should be aware of school and district funding policies and procedures to determine how much money is available for their needs. Funding for various purposes, including the purchase of learning resources, is provided to school districts. Learning resource selection should be viewed as an ongoing process that requires a determination of needs, as well as long-term planning to co-ordinate individual goals and local priorities.

What Kinds of Resources Are Found in a Grade Collection?
The Grade Collection charts list the recommended learning resources by media format, showing links to the curriculum organizers and suborganizers. Each chart is followed by an annotated bibliography. Teachers should check with suppliers for complete and up-to-date ordering information. Most suppliers maintain web sites that are easy to access.

CHEMISTRY 11 AND 12 GRADE COLLECTIONS

The Grade Collections for Chemistry 11 and 12 list the recommended learning resources for these courses. Resources previously recommended for the 1995 version of the curriculum, where still valid, continue to support this updated IRP. The ministry updates the Grade Collections on a regular basis as new resources are developed and evaluated.

Please check the following ministry web site for the most current list of recommended learning resources in the Chemistry 11 and 12 Grade Collections: www.bced.gov.bc.ca/irp_resources/lr/resource/gradcoll.htm