Chemistry 121-122 Curriculum

Implemented September 2009

New Nouveau Brunswick
Be...in this place • Être...ici on le peut

2009
Department of Education
Educational Programs and Services Branch
Additional copies of this document may be obtained using the Title Code 844450

Acknowledgements

Under the Atlantic Provinces Education Foundation (APEF) common curriculum agreement, the province of Nova Scotia was the lead province in the development of the high school Chemistry Curriculum guide for the Atlantic Provinces. The Department of Education of New Brunswick gratefully acknowledges the contributions of the members of the local and regional chemistry committees in the Atlantic Provinces for their professional expertise and insights in developing these guides. We also acknowledge the contribution of the PEI Department of Education who have also made available supporting laboratory guides for the use of NB teachers. Special thanks go to the following people who were involved in the revisions and development of the New Brunswick guides as members of the NB High School Science Curriculum Development Advisory committee, or as piloting teachers:

Vicki Atkinson	Teacher, Kennebecasis Valley High School, Quispamsis
Myra Beckett	Teacher, Rothesay High School, Rothesay
Alexis Christmas	Teacher, Fredericton High School, Fredericton
Kim Cripps	Teacher, Miramichi Valley High School, Miramichi
Paul Dunnett	Teacher, Kennebecasis High School, Quispamsis
Anne Furlotte	Teacher, Bathurst High School, Bathurst
Kris Gallagher	Teacher, Southern Victoria High School, Perth-Andover
Vance Jessome	Teacher, Chipman Forest Avenue School, Chipman
Paul Kettela	Teacher, Woodstock High School, Woodstock
Jonathan Logan	Teacher, Sir James Dunn Academy, St. Andrews
Martha McClure	New Brunswick Department of Education, Fredericton
Chris Mclaughlin	Teacher, Southern Victoria High School, Perth-Andover
Debby Peck	PhD Candidate, Science Education, UNB, Fredericton
Michael Swift	Teacher, Sussex Regional High School, Sussex
Nancy Vessie	Teacher, Miramichi Valley High School, Miramichi

Chemistry 121 – 122 Curriculum

Part 1

The Teaching Framework

Table of Contents

Introduction

Background

The curriculum described in *Foundation for the Atlantic Canada Science Curriculum* was planned and developed collaboratively by regional committees. The process for developing the common science curriculum for Atlantic Canada involved regional consultation with the stakeholders in the education system in each Atlantic province. The Atlantic Canada science curriculum is consistent with the science framework described in the pan-Canadian *Common Framework of Science Learning Outcomes K to 12.*

The development of these curricula involved further revision of the *Atlantic Canada Science Curriculum* for Chemistry 11 and Chemistry 12, in consultation with educators in New Brunswick over a 3-year period (as listed in the Acknowledgements).

Rationale

The aim of science education in the Atlantic provinces is to develop scientific literacy.

Scientific literacy is an evolving combination of the science-related attitudes, skills, and knowledge students need to develop inquiry, problem-solving, and decision-making abilities; to become life-long learners; and to maintain a sense of wonder about the world around them. To develop scientific literacy, students require diverse learning experiences which provide opportunity to explore, analyze, evaluate, synthesize, appreciate, and understand the interrelationships among science, technology, society, and the environment that will affect their personal lives, their careers, and their future.

Program Design & Components

Learning and Teaching Science

What students learn is fundamentally connected to how they learn it. The aim of scientific literacy for all has created a need for new forms of classroom organization, communication, and instructional strategies.

The teacher is a facilitator of learning whose major tasks include:

- creating a classroom environment to support the learning and teaching of science
- designing effective learning experiences that help students achieve designated outcomes
- stimulating and managing classroom discourse in support of student learning
- learning about and then using students' motivations, interests, abilities, and learning styles to improve learning and teaching
- analyzing student learning, the scientific tasks and activities involved, and the learning environment to make ongoing instructional decisions
- selecting teaching strategies from a wide repertoire

Effective science learning and teaching take place in a variety of situations. Instructional settings and strategies should create an environment which reflects a constructive, active view of the learning process. Learning occurs not by passive absorption, but rather as students actively construct their own meaning and assimilate new information to develop new understanding.

The development of scientific literacy in students is a function of the kinds of tasks they engage in, the discourse in which they participate, and the settings in which these activities occur. Students' disposition towards science is also shaped by these factors. Consequently, the aim of developing scientific literacy requires careful attention to all of these facets of curriculum.

Learning experiences in science education should vary and include opportunities for group and individual work, discussion among students as well as between teacher and students, and hands-on/minds-on activities that allow students to construct and evaluate explanations for the phenomena under investigation. Such investigations and the evaluation of the evidence accumulated, provide opportunities for students to develop their understanding of the nature of science and the nature and status of scientific knowledge.

The Three Processes of Scientific Literacy

An individual can be considered scientifically literate when he/she is familiar with, and able to engage in, three processes: inquiry, problem solving, and decision making.

Inquiry

Scientific inquiry involves posing questions and developing explanations for phenomena. While there is general agreement that there is no such thing as the scientific method, students require certain skills to participate in the activities of science. Skills such as questioning, observing, inferring, predicting, measuring, hypothesizing, classifying, designing experiments, collecting data, analyzing data, and interpreting data are fundamental to engaging in science. These activities provide students opportunity to understand and practice the process of theory development in science and the nature of science.

Problem Solving

The process of problem solving involves seeking solutions to human problems. It consists of the proposing, creating, and testing of prototypes, products and techniques in an attempt to reach an optimum solution to a given problem.

Decision Making

The process of decision making involves determining what we, as citizens, should do in a particular context or in response to a given situation. Decision-making situations are not only important in their own right. They also provide a relevant context for engaging in scientific inquiry and/or problem solving.

Meeting the Needs of All Learners

Foundation for the Atlantic Canada Science Curriculum stresses the need to design and implement a science curriculum that provides equal opportunities for all students according to their abilities, needs and interests. Teachers must be aware of and make adaptations to accommodate the diverse range of learners in their class. In order to adapt to the needs of all learners, teachers must create opportunities that would permit students to have their learning styles addressed.

As well, teachers must not only remain aware of and avoid gender and cultural biases in their teaching, they must strive to actively address cultural and gender stereotyping regarding interest and success in science and mathematics. Research supports the position that when science curriculum is made personally meaningful, and socially and culturally relevant, it is more engaging for groups traditionally under-represented in science, and indeed, for all students.

When making instructional decisions, teachers must consider individuals' learning needs, preferences and strengths, and the abilities, experiences, interests, and values that learners bring to the classroom. Ideally, every student should find his/her learning opportunities maximized in the science classroom.

While this curriculum guide presents specific outcomes for each unit, it must be acknowledged that students will progress at different rates. Teachers should provide materials and strategies that accommodate student diversity, and validate students when they achieve the outcomes to the maximum of their abilities.

It is important that teachers articulate high expectations for all students and ensure that all students have equitable opportunities to experience success as they work toward the achievement of designated outcomes. A teacher should adapt classroom organization, teaching strategies, assessment practices, time, and learning resources to address students' needs and build on their strengths. The variety of learning experiences described in this guide provides access for a wide range of learners. Similarly, the suggestions for a variety of assessment practices provide multiple ways for learners to demonstrate their achievements.

Assessment and Evaluation

The terms assessment and evaluation are often used interchangeably, but they refer to quite different processes. Science curriculum documents developed in the Atlantic region use these terms for the processes described below.

Assessment is the systematic process of gathering information on student learning.

Evaluation is the process of analyzing, reflecting upon, and summarizing assessment information, and making judgments or decisions based upon the information gathered.

The assessment process provides the data and the evaluation process brings meaning to the data. Together, these processes improve teaching and learning. If we are to encourage enjoyment in learning for students, now and throughout their lives, we must develop strategies to involve students in assessment and evaluation at all levels. When students are aware of the outcomes for which they are responsible, and the criteria by which their work will be assessed or evaluated, they can make informed decisions about the most effective ways to demonstrate their learning.

Regional curriculum in science suggests experiences that support learning within STSE, skills, knowledge and attitudes. It also reflects the three major processes of science learning: inquiry, problem solving and decision making. When assessing student progress it is helpful to know some activities/skills/actions that are associated with each process of science learning. Examples of these are illustrated in the following lists. Student learning may be described in terms of ability to perform these tasks.

Inquiry

- define questions related to a topic
- refine descriptors/factors that focus practical and theoretical research
- select an appropriate way to find information
- make direct observations
- perform experiments, record and interpret data, and draw conclusions
- design an experiment which tests relationships and variables
- write lab reports that meet a variety of needs (limit the production of "formal" reports) and place emphasis on recorded data
- recognize that both quality of both the process and the product are important

Problem Solving

- clearly define a problem
- produce a range of potential solutions for the problem
- appreciate that several solutions should be considered
- plan and design a product or device intended to solve a problem
- construct a variety of acceptable prototypes, pilot test, evaluate and refine to meet a need
- present the refined process/product/device and support why it is "preferred"
- recognize that both quality of both the process and the product are important

Decision Making

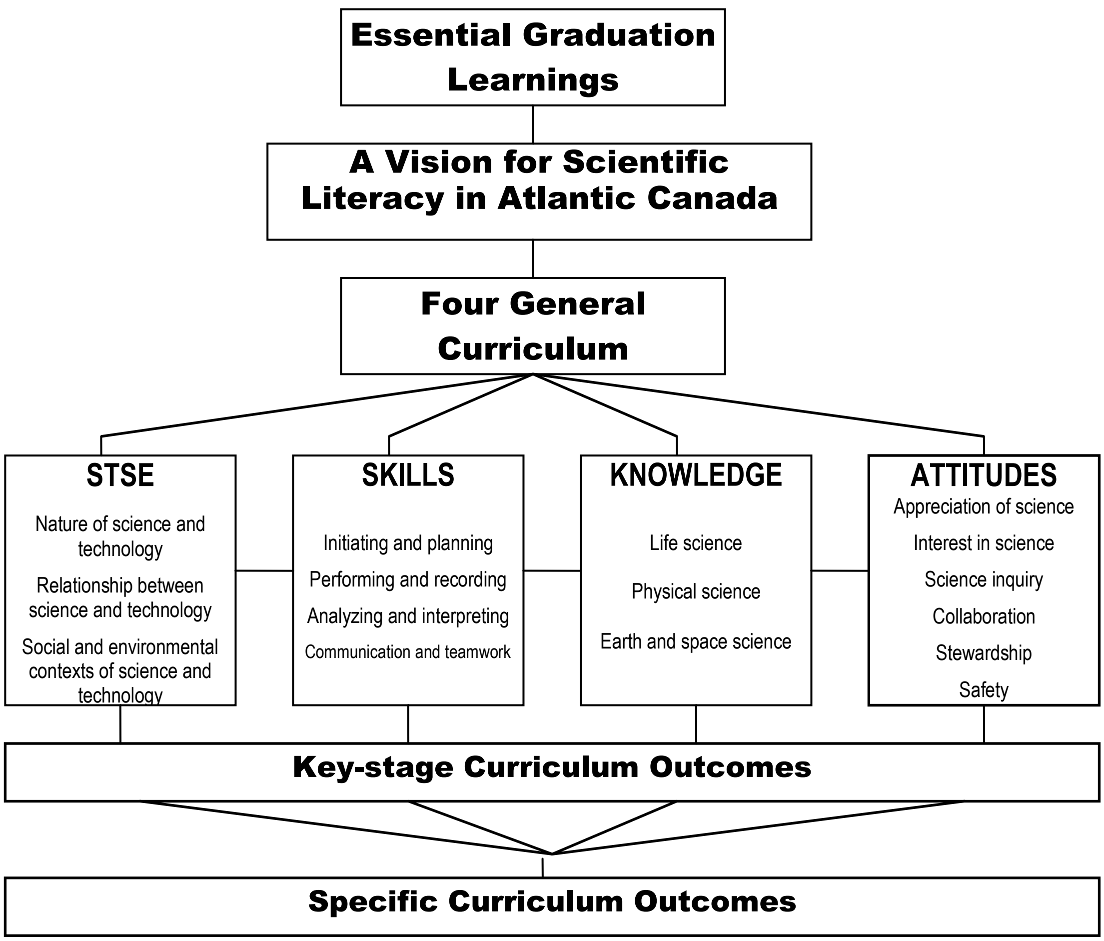
- gather information from a variety of sources
- evaluate the validity of the information source
- evaluate which information is relevant
- identify the different perspectives that influence a decision
- present information in a balanced manner
- use information to support a given perspective
- recommend a decision and provide supporting evidence
- communicate a decision and provide a "best" solution

Outcomes

Outcomes Framework

The science curriculum is based on an outcomes framework that includes statements of essential graduation learnings, general curriculum outcomes, key-stage curriculum outcomes, and specific curriculum outcomes. The general, key-stage, and specific curriculum outcomes reflect the pan-Canadian Common Framework of Science Learning Outcomes K to 12. The conceptual map shown in Figure 1 provides the blueprint of the outcomes framework.

FIGURE 1



This curriculum guide outlines grade level specific curriculum outcomes, and provides suggestions for learning, teaching, assessment and resources to support students' achievement of these outcomes. Teachers should consult the *Foundation for the Atlantic Canada Science Curriculum* for descriptions of the essential graduation learnings, vision for scientific literacy, general curriculum outcomes, and key-stage curriculum outcomes.

Curriculum Guide Organization

Specific curriculum outcome statements describe what students should know and be able to do at each grade level. They are intended to serve as the focus for the design of learning experiences and assessment tasks. Specific curriculum outcomes represent a reasonable framework for assisting students to achieve the key-stage, the general curriculum outcomes, and ultimately the essential graduation learnings.

Specific curriculum outcomes are organized in two to four units for each grade level. Each unit is organized by topic. Suggestions for learning, teaching, assessment, and resources are provided to support student achievement of the outcomes.

The order in which the units of a grade appear in the guide is meant to suggest a sequence. In some cases the rationale for the recommended sequence is related to the conceptual flow across the year. That is, one unit may introduce a concept which is then extended in a subsequent unit. Likewise, it is possible that one unit focuses on a skill or context which will then be built upon later in the year.

It is also possible that units or certain aspects of units can be combined or integrated. This is one way of assisting students as they attempt to make connections across topics in science or between science and the real world.

Extended time frames may be needed to collect data over time. These cases may warrant starting the activity prior to the unit in which it will be used. In all cases logical situations and contexts should be taken into consideration when these types of decisions are made.

The intent is to provide opportunities for students to deal with science concepts and scientific issues in personally meaningful, and socially and culturally, relevant contexts.

Unit Organization

All units comprise a two-page layout of four columns as illustrated in Figure 2. Each unit is comprised of outcomes grouped by a topic which is indicated at the top of the left page.

Column One: Essential Learning Outcomes

The first column lists a group of ***NB prescribed outcomes*** that relate to the pan-Canadian *Specific Curriculum Outcomes* listed at the beginning of each unit. These are based on the pan-Canadian *Common Framework of Science Learning Outcomes K to 12.* This column also includes appropriate extensions for those students enrolled in ***Chemistry 111*** or ***Chemistry 121***. The statements involve the Science-Technology-Society-Environment (STSE), skills, and knowledge outcomes indicated by the outcome number(s) that appears in brackets after the outcome statement.

Curriculum outcomes for each unit have been grouped by topic. Other groupings of outcomes are possible and in some cases may be necessary in order to take advantage of local situations. The grouping of outcomes provides a suggested teaching sequence. Teachers may prefer to plan their own teaching sequence to meet the learning needs of their students.

Column Two: Elaborations

The second column includes **Elaborations** of the outcomes, as well as background information These Elaborations explain further the depth of understanding that students should acquire. Also included in this column are **Teaching Suggestions**, and ***Optional*** extensions of the topic. The suggestions in this column are intended to provide a holistic approach to instruction. In some cases, the suggestions in this column address a single outcome; in other cases, they address a group of outcomes.

Column Three: Tasks for Instruction and/or Assessment

The third column provides suggestions for ways that students' achievement of the outcomes could be taught and assessed. These suggestions reflect a variety of assessment techniques which include, but are not limited to, informal/formal observation, performance, journals, interview, paper and pencil, presentations, and portfolio. Some assessment tasks may be used to assess student learning in relation to a single outcome, others to assess student learning in relation to several outcomes. The assessment item identifies the outcome(s) addressed by the outcome number in brackets after the item.

Column Four: Notes

This column will refer teachers to the supporting text and ancillary resources. For current useful websites, and shared teacher resources, teachers are directed to the NB government Teacher Portal at: https://portal.nbed.nb.ca/

FIGURE 2
Curriculum Outcomes Organization:
The Four-Column, Two-Page Spread

Topic			
NB Prescribed Outcomes	***Elaborations***	***Tasks for Instruction and/or Assessment***	***Notes***
• Outcomes based on Pan-Canadian Specific Learning Outcomes • Additional outcomes for Level 1 course • Optional outcomes to be completed after completion of above outcomes	Elaborations of outcomes listed in column one Teaching Suggestions	Informal/Formal Observation Performance Journal Interview Paper and Pencil Presentation Portfolio	References to prescribed text and supporting resources. References to Appendices.

Unit Overview

At the beginning of each unit, there is a two-page synopsis. On the first page, introductory paragraphs give a unit overview. These are followed by a section that specifies the focus (inquiry, problem solving, and/or decision making) and possible contexts for the unit. Finally, a curriculum links paragraph specifies how this unit relates to science concepts and skills that will be addressed at later grades so teachers will understand how the unit fits with the students' progress through the complete science program.

The second page of the two-page overview provides a table of the outcomes from the *Common Framework of Science Learning Outcomes K to 12* that will be addressed in the unit. The numbering system used is the one followed in the pan-Canadian document:

100s - Science-Technology-Society-Environment (STSE) outcomes

200s - Skills outcomes

300s - Knowledge outcomes

400s- Attitude outcomes (see pages 10-18)

These code numbers appear in brackets after each specific curriculum outcome (SCO).

FIGURE 3
Unit Overview

Unit Title: Unit Overview		**Unit Title: Pan Canadian Specific Curriculum Outcomes**		
Introduction Focus and Contexts Curriculum Links	Synopsis of the unit Focus: Inquiry, Decision Making, or Problem Solving. Possible contexts suggested Links to concepts studied within the K-12 science curriculum	**STSE** ### Science –Technology – Society -Environment outcomes from C*ommon Framework of Science Learning Outcomes K to 12*	**Skills** ### Skills outcomes from *Common Framework of Science Learning Outcomes K to 12*	**Knowledge** ###Knowledge outcomes from *Common Framework of Science Learning Outcomes K to 12*

Attitude Outcomes

It is expected that certain attitudes will be fostered and developed throughout the entire science program, entry to grade 12. The STSE, skills and knowledge outcomes contribute to the development of attitudes, and opportunities for fostering these attitudes are highlighted in the *Suggestions for Learning and Teaching* section of each unit.

Attitudes refer to generalized aspects of behaviour that are modeled for students by example and reinforced by selective approval. Attitudes are not acquired in the same was as skills and knowledge. The development of positive attitudes plays an important role in students' growth by interacting with their intellectual development and by creating a readiness for responsible application of what they learn.

Since attitudes are not acquired in the same way as skills and knowledge, outcomes statements for attitudes are written for the end of grades 3, 6, 9 and 12. These outcomes statements are meant to guide teachers in creating a learning environment that fosters positive attitudes.

The following pages present the attitude outcomes from the pan-Canadian *Common Framework of Science Learning Outcomes K to 12.*

Common Framework of Science Learning Outcomes K-12
Attitude Outcome Statements

From entry through grade 3 it is expected that students will be encouraged to…

Appreciation of science	Interest in science	Scientific inquiry
400 recognize the role and contribution of science in their understanding of the world ***Evident when students, for example,*** – give examples of science in their own lives – give examples of how objects studied and investigations done in class relate to the outside world – recognize that scientific ideas help us to explain how or why events occur	401 show interest in and curiosity about objects and events within the immediate environment 402 willingly observe, question, and explore ***Evident when students, for example,*** – ask "why" and "how" questions about observable events – ask many questions related to what is being studied – participate in show-and-tell activities, bringing objects from home or sharing a story or an observation – ask questions about what scientists do – express enjoyment from being read to from science books – seek out additional information from library books and digital discs – express enjoyment in sharing science-related information gathered from a variety of sources, including discussions with family members and friends – ask to use additional science equipment to observe objects in more detail – express the desire to find answers by exploring and conducting simple experiments	403 consider their observations and their own ideas when drawing a conclusion 404 appreciate the importance of accuracy 405 be open-minded in their explorations ***Evident when students, for example,*** – raise questions about the world around them – willingly record observations in a given format – compare results of an experiment with other classmates – use observations to draw a conclusion or verify a prediction – take the time to measure with care – willingly explore a change and its effects – choose to follow directions when they complete a simple investigation – express the desire to find answers by conducting simple experiments

Common Framework of Science Learning Outcomes K-12
Attitude Outcome Statements

From entry through grade 3 It is expected that students will be encouraged to…

Collaboration	Stewardship	Safety
406 work with others in exploring and investigating ***Evident when students, for example*,** – willingly share ideas and materials – respond positively to others' questions and ideas – take on and fulfil a variety of roles within the group – participate in science-related activities with others, regardless of their age or their physical or cultural characteristics – respond positively to other people's views of the world	407 be sensitive to the needs of other people, other living things, and the local environment ***Evident when students, for example,*** – ensure that living things are returned to an adequate environment after a study is completed – demonstrate awareness of the need for recycling and willingness to take action in this regard – show concern for other students' feelings or needs – care for living things that are kept in their classroom – clean reusable materials and store them in a safe place – willingly suggest how we can protect the environment	408 show concern for their safety and that of others in carrying out activities and using materials ***Evident when students, for example*,** – are attentive to the safe use of materials – insist that classmates use materials safely – act with caution in touching or smelling unfamiliar materials, refrain from tasting them, and encourage others to be cautious – point out to others simple and familiar safety symbols – put materials back where they belong – follow given directions for set-up, use, and clean-up of materials – wash hands before and after using materials, as directed by teacher – seek assistance immediately for any first aid concerns like cuts, burns, and unusual reactions – keep the work station uncluttered, with only appropriate materials present

Common Framework of Science Learning Outcomes K-12
Attitude Outcome Statements

From grades 4-6 It is expected that students will be encouraged to…

Appreciation of science	Interest in science	Scientific inquiry
409 appreciate the role and contribution of science and technology in their understanding of the world 410 realize that the applications of science and technology can have both intended and unintended effects 411 recognize that women and men of any cultural background can contribute equally to science ***Evident when students, for example,*** – recognize that scientific ideas help explain how and why things happen – recognize that science cannot answer all questions – use science inquiry and problem-solving strategies when given a question to answer or a problem to solve – plan their actions to take into account or limit possible negative and unintended effects – are sensitive to the impact their behaviour has on others and the environment when taking part in activities – show respect for people working in science, regardless of their gender, their physical and cultural characteristics, or their views of the world – encourage their peers to pursue science-related activities and interests	412 show interest and curiosity about objects and events within different environments 413 willingly observe, question, explore, and investigate 414 show interest in the activities of individuals working in scientific and technological fields ***Evident when students, for example,*** – attempt to answer their own questions through trial and careful observation – express enjoyment in sharing and discussing with classmates science-related information – ask questions about what scientists in specific fields do – express enjoyment in reading science books and magazines – willingly express their personal way of viewing the world – demonstrate confidence in their ability to do science – pursue a science-related hobby – involve themselves as amateur scientists in exploration and scientific inquiry, arriving at their own conclusions rather than those of others	415 consider their own observations and ideas as well as those of others during investigations and before drawing conclusions 416 appreciate the importance of accuracy and honesty 417 demonstrate perseverance and a desire to understand ***Evident when students, for example***, –ask questions to clarify their understanding – respond constructively to the questions posed by other students – listen attentively to the ideas of other students and consider trying out suggestions other than their own – listen to, recognize, and consider differing opinions – open-mindedly consider non-traditional approaches to science – seek additional information before making a decision – base conclusions on evidence rather than preconceived ideas or hunches – report and record what is observed, not what they think ought to be or what they believe the teacher expects – willingly consider changing actions and opinions when presented with new information or evidence – record accurately what they have seen or measured when collecting evidence – take the time to repeat a measurement or observation for confirmation or greater precision – ask questions about what would happen in an experiment if one variable were changed – complete tasks undertaken or all steps of an investigation

Common Framework of Science Learning Outcomes K-12
Attitude Outcome Statements

From grades 4-6 It is expected that students will be encouraged to…

Collaboration	**Stewardship**	**Safety**
418 work collaboratively while exploring and investigating ***Evident when students, for example,*** – participate in and complete group activities or projects – willingly participate in cooperative problem solving – stay with members of the group during the entire work period – willingly contribute to the group activity or project – willingly work with others, regardless of their age, their gender or their physical or cultural characteristics – willingly consider other people's views of the world	419 be sensitive to and develop a sense of responsibility for the welfare of other people, other living things, and the environment ***Evident when students, for example,*** – choose to have a positive effect on other people and the world around them – frequently and thoughtfully review the effects and consequences of their actions – demonstrate willingness to change behaviour to protect the environment – respect alternative views of the world – consider cause and effect relationships that exist in environmental issues – recognize that responding to their wants and needs may negatively affect the environment – choose to contribute to the sustainability of their community through individual positive actions – look beyond the immediate effects of an activity and identify its effects on others and the environment	420 show concern for their safety and that of others in planning and carrying out activities and in choosing and using materials 421 become aware of potential dangers ***Evident when students, for example,*** – look for labels on materials and seek help in interpreting them – ensure that all steps of a procedure or all instructions given are followed – repeatedly use safe techniques when transporting materials – seek counsel of the teacher before disposing of any materials – willingly wear proper safety attire, when necessary – recognize their responsibility for problems caused by inadequate attention to safety procedures – stay within their own work area during an activity, to minimize distractions and accidents – immediately advise the teacher of spills, breaks, or unusual occurrences – share in cleaning duties after an activity – seek assistance immediately for any first aid concerns like cuts, burns, and unusual reactions – keep the work station uncluttered, with only appropriate materials present

Common Framework of Science Learning Outcomes K-12
Attitude Outcome Statements

For grades 7-9 It is expected that students will be encouraged to…

Appreciation of science	Interest in science	Scientific inquiry
422 appreciate the role and contribution of science and technology in our understanding of the world 423 appreciate that the applications of science and technology can have advantages and disadvantages 424 appreciate and respect that science has evolved from different views held by women and men from a variety of societies and cultural backgrounds ***Evident when students, for example,*** – recognize the potential conflicts of differing points of view on specific science-related issues – consider more than one factor or perspective when formulating conclusions, solving problems, or making decisions on STSE issues – recognize the usefulness of mathematical and problem-solving skills in the development of a new technology – recognize the importance of drawing a parallel between social progress and the contributions of science and technology – establish the relevance of the development of information technologies and science to human needs – recognize that science cannot answer all questions – consider scientific and technological perspectives on an issue – identify advantages and disadvantages of technology – seek information from a variety of disciplines in their study – avoid stereotyping scientists – show an interest in the contributions women and men from many cultural backgrounds have made to the development of science and technology	425 show a continuing curiosity and interest in a broad scope of science-related fields and issues 426 confidently pursue further investigations and readings 427 consider many career possibilities in science- and technology-related fields ***Evident when students, for example,*** – attempt at home to repeat or extend a science activity done at school – actively participate in co-curricular and extra-curricular activities such as science fairs, science clubs, or science and technology challenges – choose to study topics that draw on research from different science and technology fields – pursue a science-related hobby – discuss with others the information presented in a science show or on the Internet – attempt to obtain information from a variety of sources – express a degree of satisfaction at understanding science concepts or resources that are challenging – express interest in conducting science investigations of their own design – choose to investigate situations or topics that they find challenging – express interest in science- and technology-related careers – discuss the benefits of science and technology studies	428 consider observations and ideas from a variety of sources during investigations and before drawing conclusions 429 value accuracy, precision, and honesty 430 persist in seeking answers to difficult questions and solutions to difficult problems ***Evident when students, for example,*** – ask questions to clarify meaning or confirm their understanding – strive to assess a problem or situation accurately by careful analysis of evidence gathered – propose options and compare them before making decisions or taking action – honestly evaluate a complete set of data based on direct observation – critically evaluate inferences and conclusions, basing their arguments on fact rather than opinion – critically consider ideas and perceptions, recognizing that the obvious is not always right – honestly report and record all observations, even when the evidence is unexpected and will affect the interpretation of results – take the time to gather evidence accurately and use instruments carefully – willingly repeat measurements or observations to increase the precision of evidence – choose to consider a situation from different perspectives – identify biased or inaccurate interpretations – report the limitations of their designs – respond skeptically to a proposal until evidence is offered to support it – seek a second opinion before making a decision – continue working on a problem or research project until the best possible solutions or answers are identified

Common Framework of Science Learning Outcomes K-12
Attitude Outcome Statements

From grades 7-9 It is expected that students will be encouraged to…

Collaboration	Stewardship	Safety in science
431 work collaboratively in carrying out investigations as well as in generating and evaluating ideas ***Evident when students, for example,*** – assume responsibility for their share of the work to be done – willingly work with new individuals regardless of their age, their gender, or their physical or cultural characteristics – accept various roles within a group, including that of leadership – help motivate others – consider alternative ideas and interpretations suggested by members of the group – listen to the points of view of others – recognize that others have a right to their points of view – choose a variety of strategies, such as active listening, paraphrasing, and questioning, in order to understand others' points of view – seek consensus before making decisions – advocate the peaceful resolution of disagreements – can disagree with others and still work in a collaborative manner – are interested and involved in decision making that requires full-group participation – share the responsibility for carrying out decisions – share the responsibility for difficulties encountered during an activity	432 be sensitive and responsible in maintaining a balance between the needs of humans and a sustainable environment 433 project, beyond the personal, consequences of proposed actions ***Evident when students, for example,*** – show respect for all forms of life – consider both the immediate and long-term effects of their actions – assume personal responsibility for their impact on the environment – modify their behaviour in light of an issue related to conservation and protection of the environment – consider the cause-and-effect relationships of personal actions and decisions – objectively identify potential conflicts between responding to human wants and needs and protecting the environment – consider the points of view of others on a science-related environmental issue – consider the needs of other peoples and the precariousness of the environment when making decisions and taking action – insist that issues be discussed using a bias-balanced approach – participate in school or community projects that address STSE issues	434 show concern for safety in planning, carrying out, and reviewing activities 435 become aware of the consequences of their actions ***Evident when students, for example,*** – read the labels on materials before using them, and ask for help if safety symbols are not clear or understood – readily alter a procedure to ensure the safety of members of the group – select safe methods and tools for collecting evidence and solving problems – listen attentively to and follow safety procedures explained by the teacher or other leader – carefully manipulate materials, using skills learned in class or elsewhere – ensure the proper disposal of materials – immediately respond to reminders about the use of safety precautions – willingly wear proper safety attire without having to be reminded – assume responsibility for their involvement in a breach of safety or waste disposal procedures – stay within their own work area during an activity, respecting others' space, materials, and work – take the time to organize their work area so that accidents can be prevented – immediately advise the teacher of spills, breaks, and unusual occurrences, and use appropriate techniques, procedures, and materials to clean up – clean their work area during and after an activity – seek assistance immediately for any first aid concerns like burns, cuts, or unusual reactions – keep the work area uncluttered, with only appropriate materials present

Common Framework of Science Learning Outcomes K-12
Attitude Outcome Statements

From grades 10-12 It is expected that students will be encouraged to…

Appreciation of science	Interest in science	Scientific inquiry
436 value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not 437 appreciate that the applications of science and technology can raise ethical dilemmas 438 value the contributions to scientific and technological development made by women and men from many societies and cultural backgrounds ***Evident when students, for example,*** – consider the social and cultural contexts in which a theory developed – use a multi-perspective approach, considering scientific, technological, economic, cultural, political, and environmental factors when formulating conclusions, solving problems, or making decisions on an STSE issue – recognize the usefulness of being skilled in mathematics and problem solving – recognize how scientific problem solving and the development of new technologies are related – recognize the contribution of science and technology to the progress of civilizations – carefully research and openly discuss ethical dilemmas associated with the applications of science and technology – show support for the development of information technologies and science as they relate to human needs – recognize that western approaches to science are not the only ways of viewing the universe – consider the research of both men d women	439 show a continuing and more informed curiosity and interest in science and science-related issues 440 acquire, with interest and confidence, additional science knowledge and skills, using a variety of resources and methods, including formal research 441 consider further studies and careers in science- and technology-related fields ***Evident when students, for example,*** – conduct research to answer their own questions – recognize that part-time jobs require science- and technology-related knowledge and skills – maintain interest in or pursue further studies in science – recognize the importance of making connections between various science disciplines – explore and use a variety of methods and resources to increase their own knowledge and skills – are interested in science and technology topics not directly related to their formal studies – explore where further science- and technology-related studies can be pursued – are critical and constructive when considering new theories and techniques – use scientific vocabulary and principles in everyday discussions – readily investigate STSE issues	442 confidently evaluate evidence and consider alternative perspectives, ideas, and explanations 443 use factual information and rational explanations when analysing and evaluating 444 value the processes for drawing conclusions ***Evident when students, for example,*** – insist on evidence before accepting a new idea or explanation – ask questions and conduct research to confirm and extend their understanding – criticize arguments based on the faulty, incomplete, or misleading use of numbers – recognize the importance of reviewing the basic assumptions from which a line of inquiry has arisen – expend the effort and time needed to make valid inferences – critically evaluate inferences and conclusions, cognizant of the many variables involved in experimentation – critically assess their opinion of the value of science and its applications – criticize arguments in which evidence, explanations, or positions do not reflect the diversity of perspectives that exist – insist that the critical assumptions behind any line of reasoning be made explicit so that the validity of the position taken can be judged – seek new models, explanations, and theories when confronted with discrepant events or evidence

Common Framework of Science Learning Outcomes K-12
Attitude Outcome Statements

For grades 10-12 It is expected that students will be encouraged to…

Collaboration	Stewardship	Safety
445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas ***Evident when students, for example,*** – willingly work with any classmate or group of individuals regardless of their age, gender, or physical and cultural characteristics – assume a variety of roles within a group, as required – accept responsibility for any task that helps the group complete an activity – give the same attention and energy to the group's product as they would to a personal assignment – are attentive when others speak – are capable of suspending personal views when evaluating suggestions made by a group – seek the points of view of others and consider diverse perspectives – accept constructive criticism when sharing their ideas or points of view – criticize the ideas of their peers without criticizing the persons – evaluate the ideas of others objectively – encourage the use of procedures that enable everyone, regardless of gender or cultural background, to participate in decision making – contribute to peaceful conflict resolution – encourage the use of a variety of communication strategies during group work – share the responsibility for errors made or difficulties encountered by the group	446 have a sense of personal and shared responsibility for maintaining a sustainable environment 447 project the personal, social, and environmental consequences of proposed action 448 want to take action for maintaining a sustainable environment ***Evident when students, for example,*** – willingly evaluate the impact of their own choices or the choices scientists make when they carry out an investigation – assume part of the collective responsibility for the impact of humans on the environment – participate in civic activities related to the preservation and judicious use of the environment and its resources – encourage their peers or members of their community to participate in a project related to sustainability – consider all perspectives when addressing issues, weighing scientific, technological, and ecological factors – participate in social and political systems that influence environmental policy in their community – examine/recognize both the positive and negative effects on human beings and society of environmental changes caused by nature and by humans – willingly promote actions that are not injurious to the environment – make personal decisions based on a feeling of responsibility toward less privileged parts of the global community and toward future generations – are critical-minded regarding the short- and long-term consequences of sustainability	449 show concern for safety and accept the need for rules and regulations 450 be aware of the direct and indirect consequences of their actions ***Evident when students, for example***, – read the label on materials before using them, interpret the WHMIS symbols, and consult a reference document if safety symbols are not understood – criticize a procedure, a design, or materials that are not safe or that could have a negative impact on the environment – consider safety a positive limiting factor in scientific and technological endeavours – carefully manipulate materials, cognizant of the risks and potential consequences of their actions – write into a laboratory procedure safety and waste-disposal concerns – evaluate the long-term impact of safety and waste disposal on the environment and the quality of life of living organisms – use safety and waste disposal as criteria for evaluating an experiment – assume responsibility for the safety of all those who share a common working environment by cleaning up after an activity and disposing of materials in a safe place – seek assistance immediately for any first aid concerns like cuts, burns, or unusual reactions – keep the work station uncluttered, with only appropriate lab materials present

Chemistry 121 – 122 Curriculum

Part 2

Daily Teaching Guide

Table of Contents

Chemistry 12 Quick Start Guide

Unit 1: Thermochemistry *(23 hours)*

1) Introduction to Thermochemistry *(4 hrs)*
The relevance of thermochemistry is introduced with the investigation of calorimetry to analyze food products. Alternative fuel energies are investigated with respect to non fossil-fuel combustion.
- Thermochemistry STSE
- Science Decisions

2) Enthalpy *(14 hrs)*
Identify and calculate energy changes associated with phase changes. The construction of heat curves and the analysis of its individual components are explored both qualitatively and quantitatively. A lab reinforces this concept through construction of a basic calorimeter. *"Heat Capacity of Calorimeter" "Heat of Reaction" "Specific Heat of a Metal"*
- Enthalpy Changes
- Thermochemistry Experimentation

3) Bonding and Hess' Law *(5 hrs)*
Theoretical enthalpy is calculated using Hess' law for instances where practical applications cannot be applied.

Unit 2: From Solutions to Kinetics to Equilibrium *(15 hours)*

1) Kinetics and Rate of Reaction *(3 hrs)*
Factors affecting the rates of reaction relating to kinetics are investigated.

2) Collision Theory, Reaction Mechanisms and Catalysts *(3 hrs)*
Collision theory and Le Châtelier's principle are used in predicting the direction of reactions.

3) Chemical Equilibrium *(9 hrs)*
Calculating equilibrium constants is used in predicting the direction of reactions.

Unit 3: Acids and Bases *(23 hours)*

1) Properties and Definitions of Acids and Bases *(4 hrs)*
Using various models (Arrhenius, and Brønsted-Lowry), students learn the various characteristics, properties and behaviors of acids and bases. The limitations of the Arrhenius Theory are identified. Individual ion concentrations are calculated based on dissociation equations.

2) Acid/Base Reactions *(4 hrs)*
The Brønsted-Lowry Theory is explored in detail. Acids, bases, conjugate acid-base pairs and amphoteric substances are identified. Students learn to predict the products of acid-base reactions by using a table of acid-base strengths.

3) OH^-, H_3O^+ and Le Châtelier *(3 hrs)*
The self-ionization of water and Kw is introduced. Illustrate the use of indicators and Le Chateliers Principle in action.

4) Using the Equilibrium Concept with Acids and Bases *(7 hrs)*
Perform calculations of pH, pOH, $[OH^-]$, $[H_3O^+]$ using Kw. Identify strong acids and bases.
Identify weak acids and bases, define % dissociation and perform calculations using Ka and Kb.
Calculate the equilibrium concentrations, pH and/or pOH of various species using initial concentrations and the equilibrium constant. (ICE problems)

Unit 3: Acids and Bases con't

5) Acid/Base Titrations *(5 hours)*
Titrations are used to reinforce empirically, the rationale of why acids and bases behave as they do. Interpret a variety of titration curves with weak and strong, acids and bases and with mono and polyprotic acids. Select the appropriate indicator for various titrations.
Use titration curves or data to predict the pH of various household substances.

Unit 4: Organic Chemistry *(24 hours)*
1) So Many Compounds *(3 hrs)* Students investigate the large number of organic compounds that result from the unique nature of carbon. Students practice building and illustrating some of these compounds.

2) Influences of Organic Chemistry on Society *(1 hr)* Natural and synthetic compounds are discussed with respect to their influence on society.

3) Classifying Organic Compounds *(2 hrs)* Compounds are classified into various families by virtue of their functional groups and structures.

4) Naming and Writing Organic Compounds *(5 hrs)* Students will name limited numbers of alkanes, alkenes, alkynes, aromatics, alkyl halides, alcohols, carboxylic acids, esters, ethers, aldehydes and ketones. Naming is demonstrated using IUPAC rules.

5) Isomers in Organic Chemistry *(2 hrs)* Students will illustrate and name structural and geometric isomers of various organic compounds.

6) Applications of Organic Chemistry *(2 hrs)* Students investigate how science and technology contributes to the production of more commercially viable products. An appropriate example of this is oil refining with its incorporation of fractional distillation, cracking and reforming.

7) Writing and Balancing Equations *(4 hrs)* Complete, balance and classify selected organic reactions. Draw the structural diagrams of all the reactants and products. Include addition, substitution, esterification, combustion, cracking and reforming.

8) Polymerization *(1 hr)* The process of polymerization is described (addition and condensation) and some important natural and synthetic polymers are identified.

9) Organic Experimentation *(2 hrs)* Design and perform an experiment. Students could synthesize an ester, aspirin, nylon,…

10) Risk and Benefit of Organic Chemistry: STSE Perspectives *(2 hrs)* Students could research the risks and benefits of various synthesized organic compounds. (Cfc's, PCB's, DDT, BPA,…)

Instructional Planning

Review of Grade 11 (5 hrs)

Unit 1 - Thermochemistry (23 hrs)

# hrs.	Chemistry 12 Curriculum Topic	PH Chemistry Text Sections	PH Chemistry Text Pages	Core Activities PH Chemistry PH Chemistry Lab Manual PEI Labs – on Portal/ Learning Resources
2	*Thermochemistry STSE*	Chapter 17.2	514, 518-519	
2	*Science Decisions*			*Research Project*
10	*Enthalpy Changes*	Chapter 17.1, 17.2, 17-3	504-517 520-526	***PEI Lab*** *"Heat Capacity of Calorimeter"* ***PEI Lab*** *"Heat of Reaction"* ***PEI Lab*** *"Specific Heat of a Metal"*
4	*Thermochemistry Experimentation*	Chapter 17.3	522 533	**Quick Lab** – p.522 *"Heat of Fusion of Ice"* **Small Scale Lab** – p.533 *"Heat of Combustion of a Candle"*
5	*Bonding and Hess"Law* *Entropy and Gibbs Free Energy(121)*	Chapter 17.4 Chapter 18.4	527-532 566-574	***PEI Lab*** *"Hess's Law"*

Unit 2 - From Solutions to Kinetics to Equilibrium (15 hrs)

# hrs.	Chemistry 12 Curriculum Topic	PH Chemistry Text Sections	PH Chemistry Text Pages	Core Activities PH Chemistry PH Chemistry Lab Manual PEI Labs – on Portal/ Learning Resources
3	*Kinetics and Rate of Reaction*	Chapter 18.1	540-548	**Inquiry Activity** – p.540 *"Temperature and Reaction Rates"* ***Lab Manual*** *– Lab 36, p.225* *"Factors Affecting Reaction Rates"* ***Lab Manual*** *– Lab 39, p.243* *"A Solubility Product Constant"*
3	*Collision Theory, Reaction Mechanisms and Catalysts* *Rate Laws (121)*	Chapter 18.4 Chapter 18.5	566-574 575-579	***Small Scale Lab Manual*** *– lab 28, p.197 "Factors Affecting the Rate of a Chemical Reaction"* ***PEI Lab*** *"The Clock Reaction"*
3	*Chemical Equilibrium (1)* K_{sp}	Chapter 18.2, 18.3 Chapter 18.3	549-565 560-565	***Small Scale Lab Manual*** *– lab 29, p.203 "Le Châtelier"s Principle and Chemical Equilibrium "* ***On-line Virtual Lab*** *"Le Châtelier"s Principle: The Chromate-Dichromate Equilibrium"* http://www.carlton.srsd119.ca/chemical/equilibrium/dichromate/dichromatelab.htm
3	*Chemical Equilibrium (2)*	Chapter 18.3	560-565	
2	*Chemical Equilibrium (3)*	Chapter 18.2	549-559	

Unit 3 - Acids and Bases (23 hrs)				
# hrs.	**Chemistry 12 Curriculum Topic**	**PH Chemistry Text Sections**	**PH Chemistry Text Pages**	**Core Activities** **PH Chemistry** **PH Chemistry Lab Manual** **PEI Labs – on Portal/ Learning Resources**
4	*Properties and Definitions of Acids and Bases*	Chapter 19.1	586-593	**PEI Lab** "Determination of pH" **Inquiry Activity** – p.586 *"Effect of Foods on Baking Soda"*
4	*Acid/Base Reactions*	Chapter 19.4	612-617	
3	*H+, OH-, and Le Châtelier*	Chapter 18.2, 19.2, 19.3	552-559 594-611	**Quick Lab** – p.604 *"Indicators from Natural Sources"* ***Lab Practical*** *19-1 "Acids, Bases, and Salts: Determining pH", Laboratory Manual Reference: Expt. 40*
7	*Using the Equilibrium Concept with Acids and Bases*	Chapter 19.3	605-611	
5	*Acid/Base Titrations* *Buffers (121)*	Chapter 19.4 Chapter 19.5	612-617 620-622	**PEI Lab** "Acid/Base Titration"
1	*Chemical Equilibrium (4)*	Appendix A	R26	

Unit 4 - Organic Chemistry *(24 hrs)*				
# hrs.	***Chemistry 12 Curriculum Topic***	***PH Chemistry Text Sections***	***PH Chemistry Text Pages***	***Core Activities*** **PH Chemistry** ***PH Chemistry Lab Manual*** ***PEI Labs – on Portal/ Learning Resources***
3	*So Many Compounds*	Chapter 22.1	693-699	**Conceptual Problem 22.2** – p. 699 *"Naming Branched-Chain Alkanes"*
1	*Influences of Organic Chemistry on Society*	Chapter 22.1, 22.5	693-695 712-717 754-755	
2	*Classifying Organic Compounds*	Chapter 22.2, 22.4	702-703 709-711	
5	*Naming and Writing Organic Compounds**	Chapter 22.1, 22.4, 23.1, 23.2, 23.3	697-699 709-711 725-743	***Lab Manual –*** *Lab 49, p.291* *"Hydrocarbons: A Structural Study"* ***PEI Lab*** *"Organic Compounds 1: Structure and Nomenclature of Organic Compounds"*
2	*Isomers in Organic Chemistry* *Optical Isomers (121)*	Chapter 22.3 Chapter 22.3	704-708 705-706	**Quick Lab –** p.707 *"Structural Isomers of Heptane"* **Small Scale Lab –** p.708 *"Hydrocarbon Isomers"*
2	*Applications of Organic Chemistry*	Chapter 22.5	712-715	***Lab Manual*** *– Lab 50, p.299* *"Esters of Carboxylic Acids"*
4	*Writing and Balancing Equations**	Chapter 22.1, 22.2, 22.4, 23.1, 23.2, 23.3, 12.2, 12.3	694-699 702-703 709-711 724-745 366, 371	***PEI Lab*** *"Ester Synthesis"*
1	*Polymerization*	Chapter 23.4	747-753	**Small Scale Lab** – p.753 *"Polymers"* ***PEI Lab*** *"Organic Compounds 2: Structure and Nomenclature of Organic Compounds"*
2	*Organic Experimentation*			*Student Designed Experiment*
2	*Risk and Benefit of Organic Chemistry: STSE Perspectives*	Chapter 22.5, 23.4	716-717 754-755	

*Note that due to the large variety of organic compounds and organic reactions, the delineations and elaborations located in the ―Naming and Writing Organic Compounds" and ―Writing and Balancing Equations" sections of this unit clearly identify the depth of study required as it relates to organic nomenclature and reactions. Nomenclature and organic reactions found in the student resource which go beyond the depth stated in the outcome elaborations should be omitted.

Chemistry 121

In addition to defining requirements for *Chemistry 122*, this curriculum document defines additional requirements for *Chemistry 121*. Throughout the document you will find additional ***Chemistry 121*** required outcomes, elaborations and labs, highlighted in blue. Unless listed as ***Optional***, all Chemistry 121 outcomes are required. ***Optional*** level 1 outcomes should only be undertaken after completing the other required level 1 outcomes.

In addition to these, each *Chemistry 121* student *must complete a chemistry research project* on a topic of their choice.

Chemistry 121 should move at an accelerated pace, and involve less repetition and practice than for *Chemistry 122*. This should free up time, which should then be used to enrich the course with more complex and challenging problems, and extension of topics and activities. This enriched curriculum should focus on an increased depth of understanding, a greater development of lab skills and investigative techniques, and greater student responsibility for research.

Curriculum adjustments

The *Quick Start Guide* and *Instructional Planning* charts found on pages 6-11 of this document, provide suggestions of how long to spend on each topic, and is based on a 90 hour course. However, recognizing that adjustments may be required due to various factors reducing instructional time, teachers are asked to follow the suggestions defined below, to ensure common adjustments are implemented across NB schools.

Unit 1:
"Thermochemistry STSE" and *"Science Decisions Involving Thermochemistry"*
 4 hrs → 2 hrs, reduce time and address in the context of other topics
Unit 2 :
"Kinetics and Rates of Reactions"
 3 hrs → 2 hrs
Unit 4:
"So Many Compounds"
 3 hrs → 2 hrs, reduce time and address in the context of other topics and linked to *"Risks and Benefits of Organic Compounds"*.
"Influences of Organic Compounds on Society" and *"Applications of Organic Chemistry"*
 3 hrs → 0 hrs, address in the context of other topics
"Risks and Benefits of Organic Compounds: STSE perspectives"
 2 hrs → 0 hrs, this can be offered instead as a student presentation or project completed outside of class time, and linked to *"So Many Compounds"*

The Four Column Spread

This curriculum document is intended as a guide to the required topics and skills to be covered in the New Brunswick Chemistry 12 course.

Column one identifies all learning outcomes for Chemistry 121 and 122. Following each outcome is a bracketed list of numbers which refers back to the “**Pan-Canadian Specific Curriculum Outcomes**” at the beginning of each unit.

In Column one, “***NB Prescribed Outcomes***” are required for all students. Those outcomes identified under “***Chemistry 121***” are required extensions of the course material for all those taking the level 1 course option. If chosen, those outcomes identified as “***Optional***” should only be undertaken after completing the other outcomes. Refer to notes on page 12 for further details if offering *Chemistry 121*.

In Column two, “**Elaborations**”, are meant to clarify the level of detail and approach to take with reference to each of the prescribed outcomes. “***Teaching Suggestions***” are optional and intended to illustrate by example the approach one could take in teaching the outcomes.

In Column three, “**Tasks for Instruction and Assessment**”, presents further suggestions for instruction and assessment to use and should be considered as optional.

Column four, titled “**Notes**”, first refers to the relevant sections of in the prescribed text: the 2008 edition of “*Prentice Hall: Chemistry*” by Wilbraham et al. **(*PH Chemistry)***.

Also listed in column four under “**Notes**”, are “**Core Activities**”. These are hands-on, and science inquiry activities that are considered a requirement for the effective teaching of this course. Those listed should be considered a minimum requirement, and a starting point. Teachers are strongly encouraged to include further science inquiry activities as they are able.

“**Core Activities**” listed can be found in the **Student text** (**PH Chemistry SE- Inquiry activity, Quick Lab, Small scale Lab**), on the **TeacherEXPRESS CD** teacher's resource (***PH Chemistry Lab Manual- Lab Manual, Small Scale Chemistry Lab Manual***), as a ***PEI Lab*** (Collected as one document for Grade 12 entitled ***Chemistry 12 Curriculum Supplement Core PEI Labs*** on the NB Government Education Portal), or as an ***On-line Virtual Lab*** (check URL address for validity before using).

In addition to these resources teachers should refer often to the NB Government Education Portal at https://portal.nbed.nb.ca/for current internet links and shared teacher resources.

Unit 1 - Thermochemistry

(23 hours)

Introduction

Energy is the essence of our existence as individuals and as a society. An abundance of fossil fuels has led to a world appetite for energy. There are pros and cons to using fossil fuels. The relationship between energy and chemistry needs to be explored to help us find alternative fuels. Thermochemistry includes energy changes that occur with physical and chemical processes. The study of energy production and the application of chemical change related to practical situations has helped society to progress.

Focus and Context

Thermochemistry focuses on energy in various systems. Skills involving planning, recording, analyzing, and evaluating energy changes will be developed. Fuels for energy provide the context for student research and projects. These fuels could include energy for industry, energy from foods, or any other relevant context. This unit will help students to develop an interest in global energy issues and to appreciate the idea of possible solutions to a problem. Doing lab work and performing calculations allows students to discuss their evidence and problem solving in order to consolidate their understanding of energy change.

Science Curriculum Links

In Science 7 Prescribed Outcomes included the explanation of temperature using the concept of kinetic energy and the particle model of matter. In Science 10, students were introduced to balancing chemical equations and the concepts of heat and temperature were developed in the context of weather topics. Chemistry 11 Prescribed Outcomes that are useful for this unit include measuring/calculating amounts of moles, and stoichiometry.

Pan-Canadian Specific Curriculum Outcomes

STSE
Students will be expected to

Nature of Science and Technology
114-5 describe the importance of peer review in the development of scientific knowledge

116-4 analyse and describe examples where technologies were developed based on scientific understanding

Social and Environmental Contexts of Science and Technology
117-6 analyse why scientific and technological activities take place in a variety of individual and group settings

117-9 analyse the knowledge and skills acquired in their study of science to identify areas of further study related to science and technology

118-2 analyse from a variety of perspectives the risks and benefits to society and the environment of applying scientific knowledge or introducing a particular technology

118-8 distinguish between questions that can be answered by science and those that cannot, and between problems that can be solved by technology and those that cannot

118-10 propose courses of action on social issues related to science and technology, taking into account an array of perspectives, including that of sustainability

Skills
Students will be expected to

Initiating and Planning
212-3 design an experiment identifying and controlling major variables

212-8 evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making

Performing and Recording
213-6 use library and electronic research tools to collect information on a given topic

213-7 select and integrate information from various print and electronic sources or from several parts of the same source

Analyzing and Interpreting
214-3 compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots

214-6 apply and assess methods of predicting heats of reaction

214-15 propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each, and select one as the basis for a plan

Communication and Teamwork
215-4 identify multiple perspectives that influence a science-related decision or issue

215-6 work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise

Knowledge
Students will be expected to

324-1 write and balance chemical equations for combustion reactions of alkanes

324-2 define endothermic reaction, exothermic reaction, specific heat, enthalpy, bond energy, heat of reaction, and molar enthalpy

324-3 calculate and compare the energy involved in changes of state and that in chemical reactions

324-4 calculate the changes in energy of various chemical reactions using bond energy, heats of formation and Hess's law

324-5 illustrate changes in energy of various chemical reactions, using potential energy diagrams

324-6 determine experimentally the changes in energy of various chemical reactions

324-7 compare the molar enthalpies of several combustion reactions involving organic compounds

Thermochemistry STSE

(2 hours)

NB Prescribed Outcomes

Students will be expected to:

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

Elaborations

The four NB Prescribed Outcomes listed here are discussed in terms of an STSE project for students. References to the project occur throughout the unit. The section, ―Science Decisions," concludes the project or can be used as a separate discussion. The NB Prescribed Outcomes are addressed as an STSE question with connections to organic chemistry.

Assign a research project for this unit based on a question such as: ―Describe a scenario where a community and/or family has to select a fuel and justify why it is best for a long-term plan". Students might work in groups for their research project. Reference to the research project can be made throughout the unit.

Students should propose courses of action on questions which they have identified, and on answers which have supporting evidence. As students look at their thermochemistry project proposal in terms of science, technology, society, and the environment, they should gain confidence in their proposal and they will likely have more unanswered questions.

Teaching suggestions

Invite students to discuss and analyse the impact of fuel on science and technology. The risks and benefits of the fuels impact from different perspectives, such as health, economic, environmental safety, and chemical, could be analyzed. A list could be made to help students with their planning.

Students could describe the science and the technology that is needed to commercially develop an energy source. An alternate perspective may be to identify an energy source and describe various science and technology considerations for its use.

Thermochemistry STSE con't

Tasks for Instruction and/or Assessment

Presentation

- Present your project using multimedia, audiovisual, or other suitable format. Present your scenario to the class. The following questions might be helpful with your thinking:
– What are the characteristics of a good chemical fuel?
– What makes your fuel a good choice?
– What is the most common method of producing your fuel?
– What are some advantages of your fuel? Some disadvantages?
– Outline the process of your fuel's development.
– What energy efficiency does your fuel have according to industry?
– What impact will the fuel have on the local environment?
(117-6, 118-2, 118-8, 118-10)

Journal

– Describe the magnitude of energy involved from physical, chemical, and nuclear processes. Provide an example of each type of energy source (equation and energy value) and identify in what context that the energy source could be used. (117-6, 118-2, 118-8, 118-10)

Notes

PH Chemistry
Chapter 17.2

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Science Decisions Involving Thermochemistry

(2 hours)

NB Prescribed Outcomes

Students will be expected to:

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

Elaborations

Teachers could address the following four NB Prescribed Outcomes as a part of their students' thermochemistry research projects as identified in the STSE section, or as a separate discussion.

Students, in groups, should identify and describe sources of energy including present sources and possible new ones. Examples might be nuclear, hydrogen, biomass, garbage, coal, peat, hydro, petroleum, natural gas, wind, and solar. They should identify the influence science has on the development of the energy source by collecting information and presenting it to their peers. Other groups could question the development and the plans for the energy.

Students should collect information through a library using books and electronic research tools, for their STSE research project or for a particular question the class wishes to discuss.

Students should cite the evidence in their research to support their positions. These sources need to be addressed as to their credibility, reliability, and specificity. For example, is a government source more or less believable than a consumer source? Suggested perspectives might be governments, industry, industrial labour force, and consumers.

Students should present their findings to the class as an overview of possibilities when deciding issues based on science. The presentation could be given as a written paper, or as a speech, brochure, short story, cartoon, or in some other form.

Science Decisions Involving Thermochemistry con't

Tasks for Instruction and/or Assessment

Paper and Pencil

- Research and organize information, and describe the science needed, to commercially develop one of the following energy sources: coal, petroleum, natural gas, sun biomass, synthetic fuels, nuclear hydrogen, seed oil, methanol, geothermal (heat pumps), oil shale. (213-6, 213-7, 118-8)

- Prepare a newspaper article about your energy source and its potential for energy production. Include information in your article about your energy source, such as its useable lifetime as a commercial source, impact on the environment, appeal to an individual consumer, and/or appeal to a community of consumers. (114-5, 213-6, 213-7, 215-4)

- Consider climatic, economic, and supply factors in your search for an energy source for the future. Include these in the research project that you began at the beginning of this unit. (114-5, 213-6, 213-7, 215-4)

Notes

Core Activities
Research Project

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

.

Enthalpy Changes (1)

(10 hours for Enthalpy Changes (1), (2), (3))

NB Prescribed Outcomes

Students will be expected to:

- define endothermic reaction, exothermic reaction, specific heat capacity, enthalpy, bond energy, heat of reaction, and molar enthalpy. (324-2)
- define thermochemistry and thermodynamics.
- differentiate between endothermic and exothermic changes.
- calculate specific heat capacity.
- use specific heat capacity in calculations.
- perform heat transfer problems.

Elaborations

Students should define thermodynamics and thermochemistry. Students should differentiate between endothermic and exothermic changes. Bond energy, enthalpy, molar enthalpy, and heat of reaction should be discussed; however, these will be referred to again later in this unit.

Students should identify everyday examples involving endothermic and exothermic changes. Example might include heating and freezing of ice, hot and cold packs, evaporation and condensation of water, and production and decomposition of ammonia.

Students should investigate heating and cooling and phase changes in terms of forces between particles, particle movement, heat content and changes in potential energy. Changes to particle movement in systems in terms of change in temperature could be introduced. Changes in potential energy in matter should be discussed; however, these will be referred to again later in this unit when calculating energy involved in changes in state.

Students should calculate specific heat capacity and perform calculations involving specific heat capacity. Students should qualitatively and quantitatively describe the resulting temperature when two substances are mixed together. The relatively high specific heat capacity of water should be investigated. Invite students to relate the importance of this quantity to issues such as climate control, heat delivery in homes, and coolant in vehicles and homes.

Teaching suggestions

Students could be introduced to a discussion of the Law of Conservation of Energy and the 1st Law of Thermodynamics. Have students pose questions about types of systems and the energy changes that occur within them.

Chemistry 121

Teaching Suggestion

Temperature probes could be used with the TI Graphing Calculators to graph temperature curves.

.

Enthalpy Changes (1) con't

Tasks for Instruction and/or Assessment

Paper and Pencil

- Distinguish between temperature(average kinetic energy) and heat (total kinetic energy) by relating these to the energy of the atoms and molecules. (324-2)
- Which has more heat: water in a 250 mL cup at 40°C or water in a 200 mL flask at 40°C? Qualitatively and quantitatively explain your result. (324-2)
- Which would cause a more severe burn: 100 g of water at 100°C or 100 g of steam at 100°C? Give reasons to support your decision. (324-2)
- Calculate the heat gained or lost from the following system:
  A cold piece of metal having a mass of 100 g, originally at –30°C, was dropped in 300 g of warm water at 35°C. The temperature of the water went down to 32°C. Calculate the specific heat of that metal. (324-2)
- Heat lost equals heat gained. Explain what assumptions are made in this statement. (324-2)
- Liquid water turns to ice. Is this endothermic or exothermic? Explain. (324-2)
- Explain what is meant by the following terms: specific heat capacity, heat of reaction, and molar enthalpy. (324-2)
- Explain why a watch glass containing ammonium nitrate feels cold when water is added. (324-2)

Journal

- A Scottish chemist, Joseph Black (1728–1799), differentiated between temperature and thermal energy. Discuss how these are different. Give an example of an experiment to show that two objects at the same temperature do not necessarily have the same thermal energy. (324-2, 212-3)
- In your journal, respond to the following questions:
  - Explain why, on a hot summer day at the beach, the sand can be unbearably hot on bare feet yet the water is very cold.
  - What happens when direct sunlight is blocked by a cloud? How does this affect the sand's versus the water's temperature? (324-2)

Presentation

- Fire in a fireplace is started by lighting crumpled paper under logs with a match. In groups, discuss the energy transfers using the terms potential energy, kinetic energy, kindling temperature, system, surroundings, endothermic, and exothermic. Present your finding to the class. (324-2)

Notes

PH Chemistry
Chapter 17.1, 17.2, 17.3
(for Enthalpy Changes (1), (2), and (3))

Core Activities
PEI Lab
"Heat Capacity of Calorimeter"
PEI Lab
"Heat of Reaction"
PEI Lab
"Specific Heat of a Metal"

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Enthalpy Changes (2)

NB Prescribed Outcomes

Students will be expected to:

- illustrate changes in energy of various chemical reactions, using potential energy diagrams. (324-5)
- identify exothermic and endothermic processes from the sign of ΔH, from thermochemical equations, and from labeled enthalpy/ potential energy diagrams.
- label enthalpy diagrams given either the ΔH for a process or a thermochemical equation.

- compile and display evidence and information on heats of formation in a variety of formats, including diagrams, flow charts, tables, and graphs. (214-3)
- write thermochemical equations including the quantity of energy exchanged given either the value of ΔH or a labeled enthalpy diagram, and vice versa.

Elaborations

Students should be able to identify exothermic and endothermic process from the sign of ΔH, from thermochemical equations, and from labeled enthalpy/potential energy diagrams. Connections should be made between these three methods of illustrating thermochemical changes.

Students should be able to label enthalpy diagrams given either the *ΔH* for a process or a thermochemical equation. Teachers might show examples that students are considering for their research project.

Students should be able to write thermochemical equations including the quantity of energy exchanged given either the value of ΔH or a labeled enthalpy diagram, and vice versa.

Teaching suggestions

Using an exothermic reaction as an example, students could use the terms high and low to represent the energy levels of the reactants and products, respectively. The student would then identify the enthalpy change for the exothermic reaction as being negative:

ΔH_{rxn}= H final(low) – H initial (high) , this value will be negative. The student should then recognize that energy was lost, or released, and as a result place the relative energy value on the product side of the thermochemical equation.

Concepts might be explored through written explanations with the diagrams and thermochemical equations. Sample tables and/or graphs are useful visual tools that might help students to clarify the concepts. Whether the diagrams are prepared by hand or computer, the presentation needs to focus on clarity, content, and readability for others' understanding.

Enthalpy Changes (2) con't

Tasks for Instruction and/or Assessment

Notes

Journal

• What types of potential energy have I used during this day? Make a chart. (214-3)

• As a living person, my energy exchange position is exothermic. Reflect on this statement. (324-5, 214-3)

Paper and Pencil

• Draw and label a potential energy (enthalpy) diagram for each of the following:
– exothermic
– endothermic (324-5, 214-3)

•Given various potential energy diagrams, determine whether the reaction is exothermic or endothermic. Identify the reactants and products, and determine the amount of energy involved. Write a verbal interpretation. (324-5, 214-3)

• Given a thermochemical equation, draw and label the corresponding energy level diagram. Identify the reactants and products, and determine the amount of energy involved. Write a verbal interpretation. (324-5, 214-3)

Presentation

• For a selected reaction, make the case that the Law of Conservation of Energy has been "upheld." Use equations and diagrams in your arguments. (324-5, 214-3)

Enthalpy Changes (3)

NB Prescribed Outcomes

Students will be expected to:

- compare the molar enthalpies of several combustion reactions involving organic compounds. (324-7)
- write and balance chemical equations for combustion reactions of alkanes, including energy amounts. (324-1)

Elaborations

Students should make a list of fossil fuels, indicate where they see these fuels used, compare the molar enthalpy of combustion values, and write combustion equations for the fuels.

Students should balance complete alkane combustion reactions using up to ten carbon atoms. Equations, including molar enthalpies of possible combustion reactions, could be identified. As students become familiar with energy and thermochemistry throughout this unit they could add to their project information. The complete combustion of hydrocarbons produces carbon dioxide, CO_2, and water, H_2O. Showing students the molar enthalpies will help them realize the importance of energy.

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$ + energy (heat)

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g) + 803kJ$

$2C_3H_6(s) + 9O_2(g) \rightarrow 6CO_2(g) + 6H_2O + 4119kJ$

- calculate and compare the energy involved in chemical reactions. (324-3)
  – write thermochemical equations to represent enthalpy notation, ΔHcomb , ΔHfus, ΔHvap .
  – calculate the heat gained or lost from a system using the thermochemical equation.

Students should write thermochemical equations to represent enthalpy notation, Δ*Hcomb* and Δ*Hfus*.

Students should define the standard molar enthalpy of various chemical processes (combustion, formation, reaction).

Students should calculate the heat gained or lost from a system using the thermochemical equation and the reaction data.

In groups, one student could calculate the heat involved from a given mass and the other could recalculate the given mass from the calculated heat term. Calculating the heat absorbed or released should be performed using the stoichiometry concepts learned in Chemistry 11.

Students should define molar enthalpy of various physical processes (soln, vap, cond, melt, freez).

- calculate and compare the energy involved in changes of state. (324-3)
  - calculate the heat gained or lost from a system using the formulas $q = mc\,\Delta T$ and $q = n\,\Delta H$.

Students should calculate the total heat for a multi-step process such as: How much heat is required to heat 50 g of ice at –20°C to steam at 120°C.

Teaching suggestions

Students could draw and label a heating/cooling curve which shows changes in kinetic and potential energy. Students could explain in words, what is happening with the heat and interpret, with words, various curves. Teachers might discuss with students the motion of particles as the substance has a temperature or state change and relate each change to the kinetic theory of matter. It is suggested that the student use the formulas $q = mc\,\Delta T$ for changes in kinetic energy (change in temperature), and $q = n\Delta H$ for changes in potential energy (changes in state).

Enthalpy Changes (3) con't

Tasks for Instruction and/or Assessment

Paper and Pencil

- Write a balanced chemical equation for the combustion reaction of each of these alkanes: methane, ethane, propane, butane, and octane. (324-1)
- Look up the molar enthalpies of the combustion of butane and octane. What do they have in common? (324-7)
- Calculate and compare the amount of heat released from the complete combustion of 1 kg of propane and 1 kg of butane. (324-1, 324-7, 324-3)
- Calculate the amount of heat released from the complete combustion of 1kg of natural gas, $CH_4(g)$, 1 kg of gasoline, use octane, $C_8H_{18}(l)$ and 1 kg of ethanol, $C_2H_5OH(l)$. Then calculate the mass of carbon dioxide produced in these reactions. Compare these fuels.
- Calculate the amount of heat involved when 2.0 g of Calcium chloride dissolves. (324-3)
- Calculate the amount of heat involved when 3.0 g of ice melts at its melting point. (324-3)
- A student wants to know how much heat energy is released when 25 kg of steam at 100°C is cooled to 25 kg of ice at –15°C. Calculate the total heat energy released. (324-3)
- Describe the processes involved in heating a substance from temperatures below its freezing point to temperatures above its boiling point. Indicate which of these processes involve change in potential energy and which involve changes in kinetic energy. (324-3b)

Journal

- Given the molar enthalpy of combustion for propane, describe what must be done prior to including the enthalpy term as a product in the thermochemical equation.

Notes

See "Notes" Enthalpy Changes (1)

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Thermochemistry Experimentation

(4 hours)

NB Prescribed Outcomes

Students will be expected to

- work cooperatively with team members to develop and carry out thermochemistry experiments (215-6)
- evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving and inquiring (212-8)
- design a thermochemistry experiment identifying and controlling major variables (212-3)
- determine experimentally the changes in energy of various chemical reactions (324-6)
- analyse the knowledge and skills acquired in their study of thermochemistry to identify areas of further study related to science and technology (117-9)
  - compare physical, chemical, and nuclear changes in terms of the species and the magnitude of energy changes involved
- propose alternative solutions to solving energy problems and identify the potential strengths and weaknesses of each (214-15)
- explain, in simple terms, the energy changes of bond breaking and bond formation

Elaborations

These NB Prescribed Outcomes are discussed in terms of thermochemistry experimentation. Students should develop an understanding of calorimetry and identify the instruments involved with calorimetry.

The Law of Conservation of Energy (1st Law of Thermodynamics), discussed earlier, are put into practical use. Observing the quantity of energy involved in physical and chemical processes will allow students to relate to the magnitude of energy involved in nuclear and biological processes.

As an introduction to calorimetry, students should perform a lab on heat of fusion of ice or wax. Having been introduced to calorimetry and calorimetry techniques, students could design an experiment to determine the specific heat capacity of a metal (e.g. a penny) or enthalpy of solution (dissolve NH_4NO_3 and/or NaOH in water). With a partner, students should select appropriate lab equipment, quantities of materials, and data in the experiments.

Having collected empirical data from various experiments, students should explore practical situations involving heat and energy transfer, such as a fire in a fireplace, solar collectors, eating food to fuel your body, or photosynthesis. Students should compare physical, chemical, and nuclear changes in terms of the species and the magnitude of energy changes involved. This works well with estimation.

Students should explain, in simple terms, the energy changes of bond breaking and bond formation. The formation of bonds and the energy could be related to why some changes are exothermic while others are endothermic. Later in this unit, students will be able to calculate the energy involved in a chemical reaction using bond energies.

Teaching suggestions

Students could perform theoretical calculations. For example, based on the energy values they obtained from their experiments, they could determine the quantity of heat that would be involved if more reactant were used.

As an introduction to calorimetry involving chemical reaction, a heat of combustion experiment could be performed such that the system and surrounding are easily identifiable. A heat of neutralization experiment or another experiment involving a chemical reaction occurring in solution could be performed.

Thermochemistry Experimentation con't

Tasks for Instruction and/or Assessment

Paper and Pencil

- As you plan one of your experiments for this unit, list the skills and knowledge needed to perform the experiment properly. (117-9)
- HCl(*aq*) + NaOH(*aq*) → NaCl(*aq*) + H_2O(*l*) When 50.0 mL of 1.00 mol/L HCl*(aq)* and 50.0 mL of 1.00 mol/L NaOH*(aq)* are mixed in a Styrofoam cup calorimeter, the temperature of the resulting solution increases from 21.0°C to 27.5°C. Calculate the heat of this reaction measured in kilojoules per mole of HCl*(aq)*. What assumptions are made during this experiment. (324-2, 324-3, 324-6)
- Define a practical problem with an energy change. Propose a solution. (214-15)

Performance

- With a partner, design a lab to calculate the molar heat of solution of NH_4NO_3 and of $CaCl_2$. Include safety issues that should be addressed. After your plan is approved, carry out your procedure and collect evidence (data) and report your findings. (212-3, 215-6, 212-8, 324-2, 324-3)
- Select and use appropriate equipment to make an inexpensive hand warmer. (Hint: Use these substances: powdered iron; H_2O; NaCl; and vermiculite.) Design your experiment. Consider safety precautions. If approval is obtained, do this experiment. Have someone test your results. (212-3, 215-6, 212-8, 324-6)

Journal

- The calorimeter is the basic instrument for measuring heat transfer. Explain how it measures heat transfer, and how it works. (212-8)
- Write the thermochemical equation for each of the experiments that you performed during this unit. (117-9, 214-15)

Portfolio

Include your laboratory report(s) in your Chemistry portfolio. (212-3, 324-6)

Notes

PH Chemistry
Chapter 17.3

Core Activities
Quick Lab – p.522
"Heat of Fusion of Ice"

Small Scale Lab – p.533
"Heat of Combustion of a Candle"

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/def ault.aspx

Bonding and Hess's Law

(5 hours)

NB Prescribed Outcomes

Students will be expected to

- calculate the changes in energy of various chemical reactions using bond energy, heats of formation, and Hess's Law (324-4)

- apply one of the methods of predicting heats of reactions to your experimentally determined lab values (214-6)
- conduct a Hess's Law experiment
- compare experimental results to theoretical calculations from heat of formation or bond energy data

- analyse and describe examples where technologies were developed based on understanding thermochemistry (116-4)

Chemistry 121

- explain Entropy and Gibbs Free Energy in relation reaction spontaneity

Elaborations

Students should demonstrate an understanding that there are different ways of determining Δ*H*: Hess's Law, average bond energy, enthalpy of formation, and use of calorimeters/experimentation.

Students should use the method of adding of chemical equations and corresponding enthalpy changes to compute the enthalpy change of the overall process, which is Hess's Law. Students might address the question, ―Why is Hess's Law useful?" Hess's Law could determine Δ*H* of a reaction that otherwise might be too difficult, expensive, or dangerous to perform.

Students should use bond energies to calculate the enthalpy change for an overall process. Propanol could be used as an example. Calculate the total energy required to break the compound into atoms. Students could calculate the overall energy change for the reaction, which is the enthalpy of combustion reaction for propanol. This might be a good application to be included in students' ongoing STSE research projects.

Students should be able to use a standard heat of formation table to predict enthalpy of reaction for a chemical change.

Students should conduct a Hess's Law experiment. Before doing their experiment involving Hess's Law, students should be aware of the instruments involved in their experiment. Students could explore new instruments/technologies that would help them to do the lab more accurately and efficiently.

Students could select an experiment suggested in Thermochemistry Experimentation, such as the heat of neutralization, and compare the experimentally determined lab value to the theoretical value obtain from heat of formation data or bond energy data.

Students should analyse and describe examples where technologies were developed. The use of ―heat sinks", which are usually metal objects attached to components of electrical circuitry which absorb and dissipate heat efficiently, is an example that could be analyzed and described.

Bonding and Hess's Law con't

Tasks for Instruction and/or Assessment

Performance

- Perform an experiment involving Hess's Law. (324-4, 214-6)

Presentation

- Create an analogy to Hess's law and present your analogy to the class. (324-4)

Journal

- Would you rather drink hot chocolate out of a cup made of glass, a ceramic mug, or a cup insulated with a Styrofoam layer? Explain your reasoning. (116-4)
- You are told to use a balance to find the mass of your substance when it is at room temperature. Explain this statement. (116-4)

Paper and Pencil

- Given the following reactions and ΔH values:
  $2NH_3(g) + 3N_2O(g) \rightarrow 4N_2(g) + 3H_2O(l)$ $\Delta H = -1012kJ$
  $2N_2O(g) \rightarrow 2N_2(g) + O_2(g)$ $\Delta H = -164kJ$ (324-4)

  Calculate ΔH, using Hess's Law for :
  $4NH_3(g) + 3O_2(g) \rightarrow 2N_2(g) + 6H_2O(l)$

- From your knowledge of standard states and from an enthalpy of formation chart, list the standard enthalpy of formation of each of the following substances: (324-4)
  a) $Cl_2(g)$ c) $CH_4(g)$ e) H_2O (g)
  b) $H_2O(l)$ d) Na(s) f) $P_4(s)$

- Calculate ΔH for the following reaction:
  $C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$ (324-4)

- Calculate the heat of formation, ΔHf, of NO_2.
  $N_2(g) + 2O_2(g) \rightarrow 2NO_2(g)$ $\Delta H = +16.2kJ$ (324-4)

- Hydrazine, $N_2H_4(g)$, is used as a fuel in liquid-fuelled rockets. It can react with $O_2(g)$ or $N_2O_4(g)$ both producing $N_2(g)$ and $H_2O(g)$.
  Write balanced chemical equations for the two reactions.
  Calculate ΔH for each reaction, using information from an enthalpy table.
  Compare the values. Which is the more efficient rocket fuel? (324-4)

- Choose one of the experiments performed during this unit and use enthalpy of formation values or bond energies to calculate a theoretical value of enthalpy of reaction. Compare the theoretical and experimental value of enthalpy of reaction. (214-6)

Portfolio

- Include your laboratory report(s) in your chemistry portfolio. (213-3, 324-6)

Notes

PH Chemistry
Chapter 17.4

Core Activities
PEI Lab
"Hess's Law"

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Unit 2 - From Solutions to Kinetics to Equilibrium

(15 hours)

Introduction

Investigation of change in the context of solutions helps students to develop their understanding about mixtures, solutions, bonding, and stoichiometry. This investigation leads to factors which affect the rates of chemical reactions, chemical equilibrium, and a quantitative treatment of reaction systems. The balance of opposing reactions in chemical equilibrium systems has issues relating to commercial/ industrial production.

Focus and Context

Many factors affect the rate of chemical reactions. Understanding that reactions can be described as dynamic equilibrium systems by criteria, equations, calculations, concentrations, and experiments within the context of everyday phenomena is the focus of this unit on solutions and equilibrium. The context might be hemoglobin at high altitudes, ammonia in the Haber process, $CaCO_3$ in caves, acids corroding metals, sodium carbonate in the Solvay process, or any other relevant context.

Problem-solving skills are used throughout this unit. Identifying variables and performing experiments to test equilibrium shifts and reaction rates are valuable to understanding this unit.

Science Curriculum Links

In Science 10, students interpreted and balanced chemical equations. Chemistry 11 introduced ions, ionic compounds, molecular structure, and solubility as well as measuring amounts in moles. In Chemistry 12, before expressing the concept of equilibrium, the concentration of solutions should be addressed.

Pan-Canadian Specific Curriculum Outcomes

STSE

Students will be expected to

Nature of Science and Technology
114-2 explain the roles of evidence, theories, and paradigms in the development of scientific knowledge

Relationships Between Science and Technology
116-2 analyse and describe examples where scientific understanding was enhanced or revised as a result of the invention of a technology

116-4 analyse and describe examples where technologies were developed based on scientific understanding

Skills

Students will be expected to

Initiating and Planning
212-9 develop appropriate sampling procedures

Performing and Recording
213-1 implement appropriate sampling procedures

213-5 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of data

214-1 describe and apply classification systems and nomenclatures used in the sciences

Knowledge

Students will be expected to

321-3 identify and discuss the properties and situations in which the rate of reaction is a factor

ACC-1 describe collision theory and its connection to factors involved in alerting reaction rates

ACC-2 describe a reaction mechanism and catalysts' role in a chemical reaction

323-3 define the concept of equilibrium as it pertains to solutions

323-4 explain solubility, using the concept of equilibrium

323-5 explain how different factors affect solubility, using the concept of equilibrium

Kinetics and Rate of Reaction

(3 hours)

NB Prescribed Outcomes

Students will be expected to

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

Elaborations

Students should identify the factors that affect rate of reaction and the ways these can be controlled (temperature, concentration, surface area, catalysts, and nature of the reactants). Students should apply their knowledge to explain reactions in different situations.

Teaching suggestions

Students could investigate the role of surface area, temperature, concentration, and catalyst by performing lab experiments such as yeast and sugar solution or antacid tablets and water. Discussion in terms of reaction kinetics would be appropriate here.

In groups of four, students could identify common reactions whose rates can be controlled and the processes used to control them. When results are presented to the class, additions or deletions could also be recorded.

Students could design and carry our experiments to collect data of the rate of a simple reaction. Interpreting their data might require a graph. Suggested reactions include a metal with an acid, baking soda with vinegar, or antacid with water.

Discussion about slow and fast chemical reactions might give information about why it is important to control the rates of reactions. Students could explore related examples such as rust prevention and an air bag reaction. Examples of reactions from biochemistry might be an interesting extension.

Kinetics and Rate of Reaction con't

Tasks for Instruction and/or Assessment

Journal

- Why is it better to use a catalyst to speed up a reaction rather than increase the temperature? (321-3)

Paper and Pencil

- When is it desirable to speed up a chemical reaction? (321-3)
- When is it desirable to slow down a chemical reaction? (321-3)
- Why is it easier to light pieces of kindling wood for a fire rather than a log? (321-3)

Paper and Pencil

- Perform an experiment that tests the factors that affect the rate of a chemical reaction. (321-3)

Portfolio

- Include your laboratory report(s) in your chemistry portfolio. (321-3)

Notes

PH Chemistry
Chapter 18.1

Core Activities
Inquiry Activity – p.540
"Temperature and Reaction Rates"

***Lab Manual** – Lab 36, p.225*
"Factors Affecting Reaction Rates"

***Lab Manual** – Lab 39, p.243*
"A Solubility Product Constant"

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Collision Theory, Reaction Mechanisms and Catalysts (1)

(3 hours for Collision Theory, Reaction, Mechanisms, and Catalysts (1) and (2))

NB Prescribed Outcomes

Students will be expected to

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

Elaborations

Students should describe the role of the following in reaction rate: nature of reactants, surface area, temperature, catalyst, and concentration. Students should perform experiments and have discussions to determine the factors that affect the rate of a chemical reaction using the kinetic molecular theory and collision theory.

Teaching suggestions

A classroom analogy could be performed where the students represent the reacting particles. The students should be asked to demonstrate an understanding of how the frequency of student collisions can be increased and how this concept can be related to collision theory and altering reaction rates. Various classroom conditions can be altered such as the area in which the ―student particles" can move (concentration), or the speed of ―student particle" movement (temperature).

Students could perform lab experiments to predict which reaction they think would be faster. Demonstrating the reactions between various solutions, students might discuss the role ―the nature of reactants" plays in the rates of reactions. Students should be able to demonstrate an understanding of the fundamentals of the kinetic molecular theory and collision theory using potential energy diagrams and energy considerations. Controlling reaction rates is important in many commercial and industrial processes. By applying collision theory to the rates of fast and slow reactions, students should be asked for complete and detailed explanations using the correct terminology.

.

Collision Theory, Reaction Mechanisms and Catalysts (1) con't

Tasks for Instruction and/or Assessment

Performance

- Students could role play as moving molecules. An example could be students moving and colliding within an entire classroom versus using only half of this space. (higher concentration)
  (ACC-1)

Presentation

- Develop an analogy to describe why certain factors affect reaction rate. (ACC-1)

Journal

- Using the kinetic molecular theory and the collision theory, describe how temperature, particle size, concentration and catalyst can be manipulated/used to increase the rate of a chemical reaction. (ACC-1)

Notes

PH Chemistry
Chapter 18.4
(for Collision Theory, Reaction Mechanisms, and Catalysts (1) and (2))

Core Activities
***Small Scale Chemistry Laboratory Manual** – lab 28, p.197*
"Factors Affecting the Rate of a Chemical Reaction"

PEI Lab
"The Clock Reaction"

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Collision Theory, Reaction Mechanisms and Catalysts (2)

NB Prescribed Outcomes

Students will be expected to

- describe a reaction mechanism and catalyst's role in a chemical reaction (ACC-2)
  - draw and label a potential energy diagram to show the effect of a catalyst on the rate of a reaction
  - define, draw, and label the following on a potential energy diagram for an exothermic and endothermic reaction: activation energy, activated complex, transition state, Δ*H*, reactants, and products
  - define reaction mechanism as a series of elementary reactions
  - identify the following components of a reaction mechanism: rate-determining step, reaction intermediates, and catalysts
  - write the overall reaction equation from a reaction mechanism

Chemistry 121

- *Demonstrate an understanding of rate laws with respect to the progress of the reaction*
- *Write the rate laws given the reaction mechanism or experimental data*
- *Identify the reaction order*

Elaborations

Students should define reaction mechanisms and show how a catalyst affects the rate of a chemical reaction by providing a different reaction mechanism. Students could research and prepare reports on catalysts used in commercial or industrial applications.

Students should draw and interpret potential energy diagrams for various reactions. Students' interpretations should include exothermic, endothermic, enthalpy, activation energy, activated complex, reactants, products, and Δ*H*.

A potential energy diagram to show the effect of a catalyst on the rate of reaction allows students the opportunity to understand the role of a catalyst on the rate of reaction. The steps of a reaction mechanism should be given and students should be able to identify the rate-determining step, reaction intermediates, and catalysts, and to add the steps of the overall reaction taking place to show that it equals the overall reaction.

Students should recognize that E and ΔE are often used in potential energy diagrams instead of H & ΔH. The use of E and ΔE are practical for all situations, particularly those in which the energy absorbed/released is in a form other than heat (e.g. light). However, when a reaction involves thermal energy, H and ΔH are commonly used.

Teaching suggestions

When discussing the fundamentals of reaction mechanisms, students might propose balanced equations for multi-step reactions (e.g., the reaction of hydrogen and bromine to form hydrogen bromide). The actual determination of a reaction mechanism is difficult and requires time. Students should realize that the reaction rate (fast or slow) involves many particles that must collide according to the balanced equation of a reaction mechanism step, and not the balanced overall equation for the reaction.

Chemistry 121

Teaching suggestions

Use graphs and experimental data to determine the rate law for the reaction. Use the rate law from the reaction to predict the reaction mechanism.

Collision Theory, Reaction Mechanisms and Catalysts (2) con't

Tasks for Instruction and/or Assessment

Paper and Pencil

- Draw and correctly label a potential energy diagram for an endothermic and exothermic reaction. Include the shape of the curve, correct labeling for activation energy and energies of reactants, products, and activated complex. (ACC-2)
- Given the following reaction mechanism, identify the:
  a) catalyst (if any)
  b) intermediate(s) and
  c) rate determining step:

STEP 1	$HCOOH + H^+ \rightarrow HCOOH_2^+$	very fast
STEP 2	$HCO_2H_2^+ \rightarrow HCO^+ + H_2O$	slow
STEP 3	$HCO^+ \rightarrow CO + H^+$	fast

- Given the above reaction mechanism, write the overall reaction equation and indicate if the equation is very fast, fast, or slow. (ACC-2)

Presentation

- Research, and prepare to discuss with the class, a catalyst role in a commercial or industrial process. (ACC-2)

Journal

- Describe the difference between a catalyst and reaction intermediate. Explain how these can be identified from a reaction mechanism. (ACC-2)

Notes

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Chemical Equilibrium (1)

(3 hours)

NB Prescribed Outcomes

Students will be expected to:

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

Elaboration

Students should compile and organize data from a laboratory activity to demonstrate an understanding of the concept of equilibrium.

Students should define equilibrium. Students should describe an equilibrium system of a solid in a saturated solution in terms of equal rates of dissolving and crystallizing. To assist in their description, they could draw a diagram illustrating solute particles entering and leaving the solution phase.

Students should compare the rate of solvation to the rate of desolvation for unsaturated solutions and for saturated solution containing excess solute. The concept of ―dynamic equilibrium" should be discussed. Although the dynamic equilibrium cannot be seen with the naked eye, students can relate to the shape of the crystals of excess solute as they change over time since solvation and desolvation occur simultaneously.

Teaching suggestions

Students might list examples of various solutions they think are in equilibrium. Students could begin with a laboratory activity involving the collection of data on equilibrium using a coloured solution, two graduated cylinders, and two glass tubes of different diameters. The glass tubes can be used to transfer the coloured liquid between the graduated cylinders until no noticeable change in volume is occurring in the cylinders (dynamic equilibrium). Verbalizing their explanations of the examples could help with their understanding of how equilibrium is established. This is an ideal opportunity for students to use graphing technology such as the TI83 graphing calculator. Students could enter the data and have the calculator plot the graphs of ―volume vs transfer" for both the forward and reverse reactions. The graphs illustrating the changes occurring during the forward and reverse reactions, as a result of the consumption of reactant and the production of product, can be view in the same window with the TI-83 calculator. Viewing both graphs simultaneously will allow students to visually identify equilibrium conditions and deepen their knowledge and understanding of the concept of equilibrium.

Students could observe the process of equilibrium by transferring volumes of water in cups between two aquariums marked as reactants and products. Students will observe when equilibrium has been established (water levels are unchanged) and the forward and reverse reactions rates (water in the cup) are equal. Students could change the forward and reverse rates by changing the size of the cups and then observe the new equilibrium position.

Chemical Equilibrium (1) con't

Tasks for Instruction and/or Assessment

Performance

- Collect and graph data from an activity involving equilibrium. (213-5, 323-3)

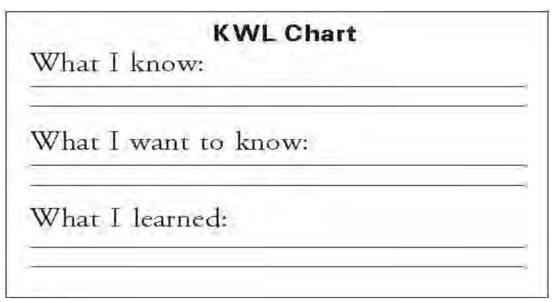
Journal

- How are solubility and equilibrium related? (323-4)
- What is the general meaning of dynamic? What is meant by dynamic equilibrium? Give examples. (323-3, 213-5)
- Is this instruction chemically correct: —Add 5 grams of sugar to your tea/coffee/lemonade, and stir until the sugar stops dissolving?" Explain. (323-3)

Paper and Pencil

- Examine and interpret the graphs found in fig. 18-10 on page 550, PH Chemistry. (213-5, 323-3)
- A chemical equilibrium is a dynamic equilibrium in which opposite processes are occurring at equal rates. Discuss the statement. What would help us to infer that the amounts of reactants and products are remaining constant at equilibrium? (114-2, 323-3)
- Prepare a short, oral presentation from the list of all the things you know about equilibrium generated in class. This is an exploratory exercise. Expectations are that you are questioning, analyzing, describing, and/or evaluating the structure using the scientific principles with which are familiar. Use a KWL chart. (214-1)

.


KWL Chart

What I know:

What I want to know:

What I learned:

Notes

PH Chemistry
Chapter 18.3

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/dfault.aspx

Chemical Equilibrium (2)

(3 hours)

NB Prescribed Outcomes

Students will be expected to:

- develop and implement appropriate sampling procedures for equilibrium expressions (213-1, 212-9)
- write equilibrium constant expressions
- predict the favourability of reactant or products in a reversible reaction, on the basis of the magnitude of the equilibrium constant

Elaborations

Students should be able to write equilibrium constant expressions. They should develop an understanding that solids and liquids are *not* included in the equilibrium expression and that the equilibrium constant will vary with temperature.

Students should be able to calculate, and perform calculations involving, an equilibrium constant, K_{eq}, (K_c) for chemical systems when (a) concentrations at equilibrium are known or (b) when initial concentrations and one equilibrium concentration are known or (c) when initial concentrations and equilibrium constant are known.

These problems may require the use of the quadratic formula ($x = (-b \pm \sqrt{b^2-4ac})/2a$); however, its use may not be needed in situations involving very small equilibrium constants. Students should be shown how to make the appropriate approximations.

Students should be able to solve K_{eq} problems involving the initial concentrations, the changes that occur in each substance, and the resulting equilibrium concentrations. These are known as ICE problems.

Chemistry 121

- Calculate the solubility product constant (Ksp) and predict precipitation

Optional

- Calculation of Equilibrium Constant using the partial pressures of gases (Kp)

Teaching suggestions

Students could use a table or chart to help with problems involving equilibrium changes. Consider the problem: What is the K_{eq} value for the following reaction at equilibrium, at 25°C?

$[H_2CO_3] = 3.3 \times 10^{-2}$ M

$[HCO_3^-] = 1.19 \times 10^{-4}$ M

$[H_3O^+] = 1.19 \times 10^{-4}$ M

$H_2CO_3(aq) + H_2O(l) \leftrightarrow H_3O^+(aq) + HCO_3^-(aq)$

When solving this K problem using H_2CO_3, students could list what they know, including the concentrations and what they want to find. Students should write the K_{eq} expression, substitute values into the expression, and solve it.

To solve K_{eq} problems involving the initial concentrations, the changes that occur in each substance, and the resulting equilibrium concentrations (ICE problems), students might use a chart like the one pictured below to organize their data. The ratio in the row C is the stoichiometric ratio.
Sample problem: What is the equilibrium concentration of this reaction: $CO_2(g) + H_2(g) \leftrightarrow CO(g) + H_2O(g)$?

Equilibrium (ICE) Table

equation	$CO_2(g) + H_2(g) \rightarrow CO(g) + H_2O(g)$			
initial concentration (I)				
change occurred (C)				
final equilibrium concentration (E)				

Chemical Equilibrium (2) con't

Tasks for Instruction and/or Assessment

Paper and Pencil

- Benzoic acid is used in food preparation. It is slightly soluble.
  The reaction is:
  $C_6H_5COOH(aq) \rightarrow H_3O^+ (aq) + C_6H_5COO^-(aq)$.
  The K_{eq} for the reaction is:
  6.30×10^{-5} at 25°C. $[C_6H_5COOH]$ is 0.020 M.
  What are the concentrations of $[H_3O^+]$ and $[C_6H_5COO^-]$? (212-9)

- What does the K_{eq} value of this reaction tell you about which side is favoured, if any? (212-9)

- Write an equilibrium constant expression for:

  CO_2 (*g*) + H_2 (*g*) ↔ H_2O (*g*) + CO (*g*) K_{eq} = 1.57 (212-9)

  N_2 (g) + $3H_2$(g) ↔ $2NH_3$(g) K_{eq} =

Performance

- Perform an experiment to determining the value of the equilibrium constant for a system in equilibrium. (212-9, 213-1)

Notes

PH Chemistry
Chapter 18.2, 18.3

Core Activities
Small Scale Chemistry Laboratory Manual *– lab 29, p.203*
"Le Châtelier's Principle and Chemical Equilibrium "

On-line Virtual Lab
"Le Châtelier's Principle: The Chromate-Dichromate Equilibrium"
http://www.carlton.srsd119.ca/chemical/equilibrium/dichromate/dichromatelab.htm

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Chemical Equilibrium (3)

(2 hours)

NB Prescribed Outcomes

Students will be expected to

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

Elaboration
Students should use Le Châtelier's Principle to determine how the concentrations of reactants and products change after a change of temperature, pressure, volume or concentrations is imposed on a system at equilibrium. Students should explain how a catalyst and the surface area have an effect on the time it takes to reach equilibrium even though these do not cause the equilibrium to shift.

It is a common misconception that a change in pressure will always affect an equilibrium. An unequal number of gaseous particle in the reactants and products are required for a change in equilibrium to be possible. It should also be noted that a change in pressure (constant volume) as the result of the addition of a gas to the reaction vessel will not shift the equilibrium if the gas is *not* involved in the equilibrium system. (i.e. the gas is not one of the reactants or products).

Students should perform an experiment involving Le Châtelier's Principle to explore how stress affects equilibrium. Students should apply Le Châtelier's Principle to various changes made to a system at equilibrium.

Teaching suggestions
Students may find it helpful to organize their observations in a table, as in the example below.

Stress Factors Effect on Equilibrium Reactions
$N_2(g) + 3H_2(g) \longleftrightarrow 2NH_3(g)$ + heat

Type of Reaction	Reactant Concentration on Increases	Product Removed	Pressure Increases	Temperature Increases
gaseous				

Chemical Equilibrium (3) con't

Tasks for Instruction and/or Assessment

Performance

- What happens when carbonated water is made? Open a bottle of soda pop and explain what you see. Write a chemical equation when equilibrium is reached between CO_2(aq) and H_2O(l) to form H_2CO_3(aq) when the container is open. Use Le Châtelier's principle to explain your observations. (114-2, 323-5)

Paper and Pencil

- In which direction will the equilibrium be shifted by an increase in (1) the concentration of O_2, (2) pressure, and (3) temperature in each of the following reactions: (323-5)

  a) $2CO\,(g) + O_2\,(g) \longleftrightarrow 2CO_2(g)$ + heat

  b) $2SO_2(g) + O_2(g) \longleftrightarrow 2SO_3(g)$ + heat

  c) $N_2(g) + O_2(g)$ + heat $\longleftrightarrow 2NO(g)$

- List the factors that can disturb an equilibrium system. (323-5)

- Why does removing a product from an equilibrium system help to produce maximum yield of that product? Refer to this example:
  $N_2\,(g) + 3H_2\,(g) \longleftrightarrow 2NH_3(g)$ + heat (114-2, 323-5)

Notes

PH Chemistry
Chapter 18.2

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Chemical Equilibrium (4)

(1 hour)

NB Prescribed Outcomes

Students will be expected to

- **analyse and describe examples where scientific understanding was enhanced or revised as a result of the invention of a technology (116-2)**

- **analyse and describe examples where technologies were developed based on scientific understanding (116-4)**

Elaborations

Students should conduct research on how our ideas of solutions and equilibrium have changed over time. Examples might include the Haber process, scuba diving, or high altitude training. Students should explain how scientific knowledge increased as a result of equilibrium evidence and theories being applied to everyday technologies.

Teaching suggestions

Students could analyse an industrial example by discussing how the technology that was developed was based on scientific understanding. The factors that control the position of a chemical equilibrium might be explored. For example, when a chemical is manufactured, the chemists and chemical engineers in charge of production want to choose conditions that favour the desired product as much as possible. They want the equilibrium to go to the right. Teachers could introduce the Haber process,

$N_2(g) + 3H_2(g) \leftarrow\rightarrow 2NH_3(g)$ + heat.

Ask questions about the process: ―How would increasing the pressure of the reaction to produce ammonia affect the ammonia yield?" and ―How would increasing the reaction temperature affect the amount of ammonia produced in this exothermic reaction?" The optimum conditions for the Haber process could be outlined.

Using their understanding of equilibrium, students could analyse and describe one of the following: limestone caves, water softeners and hard water, acclimatizing to high altitudes, and hemoglobin.

Chemistry 121

Optional

- Research the relationship between Le Châtelier's Principle and biological systems (e.g. the bends, blood O_2 levels at high altitudes).

Chemical Equilibrium (4) con’t

Tasks for Instruction and/or Assessment

Paper and Pencil

- Design a water softener. How would you deal with the problem of hard water? (116-4, 116-2)

- Research the development of modern instruments’ effect on the purification of drinking water. (116-4)

- In the early 1900’s, an endothermic process was demonstrated by Birkeland and Eyde for fixing nitrogen by passing air through a high-temperature electric arc. If a cheap electric power were available, it promised to be a rival of the Haber-Borsch process.

$$N_2\,(g) + O_2\,(g) \leftrightarrow 2NO\,(g) \quad \Delta H = +43.2 kJ$$

- According to Le Châtelier’s principle, how could the yield of NO(g) be increased? Explain. (116-2,116-4)

Notes

PH Chemistry
Appendix A (of text)

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Unit 3 - Acids and Bases

(23 hours)

Introduction

Acids and bases have an effect on aqueous systems. Acid-base systems involve proton transfer and are described quantitatively. Students will be encouraged to value the role of precise observation and careful experimentation while looking at safe handling, storage, and disposal of chemicals. There are several ways of defining acids and bases.   Problem solving and decision making are used throughout this unit.

Focus and Context

Student laboratory skills will be developed. Teachers could provide examples of products and processes that use knowledge of acids and bases. Emphasis through WHMIS could also be placed on handling these chemicals. There are many opportunities to discuss the relationships among science, technology, society, and the environment in this acid-base chemistry unit.

Science Curriculum Links

In Science 10, students will have studied writing formulas and balancing equations and be introduced to acid-base concepts. Students will have studied moles and stoichiometric calculations in Chemistry 11. The nature of solutions and expressing solution concentration will be addressed in Chemistry 12 before this acids and bases unit.

Pan-Canadian Specific Curriculum Outcomes

STSE

Students will be expected to

Nature of Science and Technology
114-2 explain the roles of evidence, theories, and paradigms in the development of scientific knowledge

114-9 explain the importance of communicating the results of a scientific or technological endeavour, using appropriate language and conventions

115-7 explain how scientific knowledge evolves as new evidence comes to light and as laws and theories are tested and subsequently restricted, revised, or replaced

Relationships Between Science and Technology
116-2 analyse and describe examples where scientific understanding was enhanced or revised as a result of the invention of a technology

Social and Environmental Contexts of Science and Technology
117-2 analyse society's influence on scientific and technological endeavours

117-7 identify and describe science- and technology-based careers related to the science they are studying

118-6 construct arguments to support a decision or judgment, using examples and evidence and recognizing various perspectives

Skills

Students will be expected to

Initiating and Planning
212-4 state a prediction and a hypothesis based on available evidence and background information

212-8 evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making

Performing and Recording
213-3 use instruments effectively and accurately for collecting data

213-8 select and use apparatus and material safely

213-9 demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials

Analyzing and Interpreting
214-1 describe and apply classification systems and nomenclature used in the sciences

214-4 identify a line of best fit on a scatter plot and interpolate or extrapolate based on the line of best fit

214-5 interpret patterns and trends in data, and infer or calculate linear and non-linear relationships among variables

214-17 identify new questions or problems that arise from what was learned

Communication and Teamwork
215-2 select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results

215-6 work co-operatively with team

Knowledge

Students will be expected to

320-1 describe various acid-base definitions up to the Brønsted-Lowry definition

320-2 predict products of acid-base reactions

320-3 compare strong and weak acids and bases using the concept of equilibrium

320-4 calculate the pH of an acid or a base given its concentration, and vice versa

320-5 describe the interactions between H^+ ions and OH^- ions using Le Châtelier's principle

320-6 determine the concentration of an acid or base solution using stoichiometry

320-7 explain how acid-base indicators function

Properties and Definitions of Acids and Bases (1)

(4 hours for Properties and Definitions of Acids and Bases (1) and (2))

NB Prescribed Outcomes

Students will be expected to

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

Elaborations
From various activities, students should define acids and bases operationally in terms of their effect on pH, taste, reactions with metals, neutralization reactions with each other, conductivity, and indicators.

Students should conduct an experiment in attempt to classify various chemicals into groups based on their properties using the following tests: conductivity, litmus paper, pH paper, Mg ribbon, and $CaCO_3$ chips. After summarizing the results in a table, students should identify each solution as acidic, basic, neutral ionic, or neutral molecular.

Students should define and identify Arrhenius acids and write ionization equations for the behaviour of Arrhenius acids in water such as:
$HNO_3\,(l) + H_2O\,(l) \rightarrow H_3O^+\,(aq) + NO_3^-(aq)$.

Students should define and identify Arrhenius bases. Students should understand that an Arrhenius base must dissociate to produce hydroxide ions in aqueous solutions. Students should write dissociation equations for the behaviour of these bases such as the following:

$$NaOH(s) \rightarrow Na^+\,(aq) + OH^-\,(aq)$$

$$Ca(OH)_2(s) \rightarrow Ca^{2+}\,(aq) + 2OH^-\,(aq)$$

Students should be made aware of the limitations of the Arrhenius definition of acids and bases. For example NH_3 is a weak base because it ionizes in water but it is not considered an Arrhenius base because it does not have a hydroxide group in the formula.

Teaching suggestions
Teachers could begin by having students write a list of all the things they know about acids and bases in their journals. Students could contribute these to a class list by suggesting things they might want to know about acids.

Students could examine the labels on various packaged food to determine which chemicals are present. They could then look up the formulas and/or do tests to determine which are acidic, basic, or neutral. To do this, the students could use the Handbook for Physics and Chemistry, The Merck Index, or Internet sites.

Properties and Definitions of Acids and Bases con't

Tasks for Instruction and/or Assessment

Performance

- Classify, using appropriate tests, the following as an acid, a base, or neutral (neither acidic or basic):
- sodium carbonate, sodium bicarbonate, calcium hydroxide, hydrochloric acid, ammonia, sulfuric acid, sugar, potassium hydroxide, sodium hydrogen sulfate, magnesium oxide solution (214-1, 320-1)

Paper and Pencil

- Write an equation for the dissociation of $Mg(OH)_2(s)$. (320-1)
- Write an equation for the dissociation of $HClO_3(aq)$. (320-1)
- How do you account for the brightness of the bulb when doing conductivity tests? (214-1, 320-1)
- What must be present in order for a solution to conduct electricity? (214-1, 320-1)
- Create an organizational chart that will assist in categorizing and naming acids. (214-1)

Presentation

- Using a concept map, organize the Arrhenius and Brønsted-Lowry acids and bases definitions. (320-1)
- Prepare a short, oral presentation from the list of all the things you know about acids and bases generated in class. This is an exploratory exercise. Expectations are that you question, analyse, describe, and/or evaluate the structure using familiar scientific principles. Use a KWL chart. (214-1)

KWL Chart

What I know:

What I want to know:

What I learned:

Performance

- Perform an experiment to observe the properties, and to develop operational definitions, of acids and bases. (214-1)

Journal

- Compare the conductivity of solutions to that of metals. (214-1, 320-1)

Notes

PH Chemistry
Chapter 19.1 *(for Properties and Definitions of Acids and Bases(1) and (2))*

Core Activities
Inquiry Activity – p.586
"Effect of Foods on Baking Soda"

PEI Lab
"Determination of pH"

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Properties and Definitions of Acids and Bases (2)

NB Prescribed Outcomes

Students will be expected to

- **explain how acid-base theory evolved as new evidence and laws and theories were tested and revised, or replaced (115-7)**
- define a Brønsted-Lowry acid and a Brønsted-Lowry base

Elaborations
The Brønsted-Lowry acid-base theory should be introduced to account for non-hydroxide bases, such as a carbonate and/or hydrogen phosphate ion.

Students should interpret equations in Brønsted-Lowry terms and identify the acid and base species. Examples should include:

$HCl\ (aq) + H_2O(l) \rightarrow H_3O^+\ (aq) + Cl^-\ (aq)$

$H_2SO_4\ (l) + H_2O(l) \rightarrow H_3O^+\ (aq) + HSO_4^-\ (aq)$

Students should define a Brønsted-Lowry acid and a Brønsted-Lowry base. By writing single-step and overall equations for the acid-base reactions of a substance that can donate/accept more than one proton, students see how each species acts as an acid or base.

Students should explain how some substances helped revise Arrhenius' theoretical definition of acids.

- **explain the roles of evidence, theories, and paradigms in acid-base theories (114-2)**
- trace the development of acid-base theories from the original Arrhenius definition to the modern revised Arrhenius concept up to the Brønsted-Lowry theory

The development of the acid-base theories up to Brønsted-Lowry should be traced to show how knowledge and thinking changed to explain new observations.

Students should define and identify amphoteric substances. Examples are given below:
(A)
water as a proton donor
$NH_3\ (aq) + \mathbf{H_2O}\ (l) \rightarrow NH_4^+ + OH^-\ (aq)$
water as a proton acceptor
$HCl(aq) + \mathbf{H_2O}\ (l) \rightarrow Cl^-\ (aq) + H_3O^+\ (aq)$

(B)
HCO_3^- *(aq)* as a proton donor
$\mathbf{HCO_3^-\ (aq)} + OH^-\ (aq) \rightarrow CO_3^{2-}\ (aq) + H_2O\ (l)$

HCO_3^- *(aq)* as a proton acceptor
$\mathbf{HCO_3^-\ (aq)} + H_2O\ (l) \rightarrow H_2\ CO_3(aq) + OH^-(aq)$

Chemistry 121

- Introduce Lewis Acid and Bases Theory as the currently accepted theory

Teaching suggestions
Students could compare the Arrhenius and Brønsted-Lowry definitions by using a chart to help with their organization of the information.

Properties and Definitions of Acids and Bases (2) con't

Tasks for Instruction and/or Assessment

Paper and Pencil

- Define the following: Brønsted-Lowry Acid; Brønsted-Lowry Base. Provide an example of each. (115-7)
- Write an equation for the ionization of the following Brønsted-Lowry bases:
  NH_3, CO_3^{2-}, HPO_4^{2-} (115-7)
- Write an equation for the ionization of the following acids: HSO_4; HCl; $HClO_4$. (115-7)
- What characteristics make a substance amphoteric? Give an example. (114-2)

Journal

- Explain why NH_3 is not considered a base according to the Arrhenius definition. (114-2)
- Although the Arrhenius definition is not comprehensive, explain its importance in developing our current understanding of acids and bases. (114-2)

Notes

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Acid/Base Reactions

(4 hours)

NB Prescribed Outcomes

Students will be expected to

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

Elaborations

Students should write chemical, ionic, and net ionic equations specific to acid-base reactions. Given two reactants, students should use a table of acid and base strengths to predict the products by first identifying which reactant will act as the acid and which will act as the base.

Consider the following reactants:

$\mathbf{HCO_3^- + HPO_4^{2-}} \leftrightarrow$?

HCO_3^- is a stronger acid and it will donate a proton to become CO_3^{2-}

HPO_4^{2-} is a stronger base (weaker acid) and it will accept a proton to become $H_2PO_4^-$

The resulting equation is:

HCO_3^- + HPO_4^{2-} $\leftrightarrow$ CO_3^{2-} + $H_2PO_4^-$

Acid + base $\leftrightarrow$ conjugate base + conjugate acid

Students might wonder why neutralization occurs between acids and bases. Students should identify the Brønsted-Lowry acid and Brønsted-Lowry base in strong acid-base neutralization reactions. Students should define and identify Brønsted-Lowry conjugate acid-base pairs.

$H_2O(l)$ + $NH_3\,(aq)$ $\rightarrow$ $NH_4^+\,(aq)$ + $OH^-\,(aq)$

acid + base $\rightarrow$ conjugate acid + conjugate base

Teaching Suggestions

Students might remember doing these various types of equations when studying solutions. Students might compare the net ionic equations from a few reactions to look for patterns. Students could identify the products of an Arrhenius acid-base neutralization.

The net ionic reaction should be

$H_3O^+\,(aq)$ + $OH^-\,(aq) \rightarrow H_2O\,(l) + H_2O\,(l)$.

This is a neutralization reaction. A clean-up of an acid spill, the antacid reaction in your stomach, or neutralizing the soil acidity in your lawn could be helpful in explaining acid-base neutralization reactions. Students should, in small groups, discuss the usefulness of acid-base reactions.

Acid-base reactions involve water, hydrogen ions, hydronium ions, and hydroxide ions. Students could compare the nature of [H^+ *(aq)*] and [H_3O^+ *(aq)*] and explain if they are the same or different. Teachers might show, how [H_3O^+] is a hydrated proton.

Acid/Base Reactions con't

Tasks for Instruction and/or Assessment

Journal

- Neutralization is a process that is controlled in lab experiments. How do you think this process works? Does it work in other environments, like a lake or your stomach? (214-17, 320-2, 114-9)

Paper and Pencil

- Identify which reactant is the Brønsted-Lowry acid and which is the Brønsted-Lowry base. (320-2)
  HSO_4^- (*aq*) + H_2O (*l*) → H_3O^+ (*aq*) + SO_4^{2-} (*aq*)
  HCN (*aq*) + H_2O (*l*) → H_3O^+ (*aq*) + CN^- (*aq*)

- Write and equation for each of the three ionization steps where phosphoric acid would donate three hydrogen (protons) ions (320-2)

- Identify which of the following act as the acid and which act as the base. Predict the products.
  HCO_3^- and HF
  $H_2PO_4^{2-}$ and CO_3^{2-}
  HNO_3 and H_2O (320-2)

Presentation

- Identify the acid, base, conjugate acid and conjugate base in the following:
  H_2O *(l)* + NH_3 *(aq)* ↔ OH^- *(aq)* + NH_4^+ (aq) (320-2)

- Illustrate the donation of a proton from an acid to a base using HCl *(aq)* and NaOH *(aq)*; HCl *(aq)* and H_2O *(aq)*; NH_3 *(aq)* and H_2O *(aq)*. (320-1, 114-9)

Notes

PH Chemistry
Chapter 19.4

<u>*Core Activities*</u>
PEI Lab
"Acid/Base Titration"

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

H^+, OH^-, and Le Châtelier

(3 hours)

NB Prescribed outcomes

Students will be expected to

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

Elaborations

The self-ionization of water produces a system at chemical equilibrium for which we can write an equilibrium constant for water, Kw. Students should write the equation for, and explain, the self-ionization of water and identify it as being amphoteric. Students might identify the extent of the self-ionization of water and note that the Kw value we use is for the equilibrium at 25°C. Students should understand that the use of a catalyst does not cause a shift in the equilibrium, and that temperature needs to be constant.

Students should write the equation for the reaction between water and the hydrogen ion to produce a hydronium ion. Students should recognize that all of the available $[H^+]$ is in the form of $[H_3O^+]$.

Students should identify the $[H^+]$ and $[OH^-]$ associated with acidic and basic solutions.

Students should look at society and the ways it influences science and technology – see teaching suggestions.

Students should identify careers that involve acid-base chemistry – see teaching suggestions.

Teaching suggestions

Students could perform a lab representing the reversible nature of the acid-base equilibrium system using an indicator, and write chemical equations representing this reversible nature. Using Le Châtelier's principle, students could predict the colour change as a result of an equilibrium shift when a strong acid or a strong base is added.

Students should look at society and the ways it influences science and technology
- by explaining the significance of strength and concentration in chemical spills, in transportation of dangerous goods, or in acid deposition.
- from a historical perspective: trace the development of the pH scale as an example of the way scientists have strived to improve communication.
- water is involved in many aspects of our lives. Students might look at various foods and chemicals in their home to see how water might be involved with each.
- an investigation of the various perspectives of food production such as additives or genetic engineering

might form the basis of a class debate or a class decision to help support a local initiative, technology, or societal endeavour.

Students should identify careers that involve acid-base chemistry of interest to them and investigate it. They might identify the use of acid-base chemistry in a particular career and defend the appropriate use of specific chemicals e.g. careers involving consumer products such as cosmetics which require a pH balance or an acidity range required for enzymes to function effectively.

H^+, OH^-, and Le Châtelier con't

Tasks for Instruction and/or Assessment

Performance

- Perform an experiment focusing on an acid-base equilibrium using Le Châtelier's principle and report your findings. (320-5)
- Act out the ionization of water. (320-5)

Paper and Pencil

- Create a chart illustrating the range of $[OH^-]$ and $[H_3O^+]$ associated with acidic, basic and neutral solutions. (320-5)
- Using Le Châtelier's principle and a diagram, explain and illustrate the shifts in equilibrium and the $[H_3O^+]$ or $[OH^-]$ resulting from the addition of acid and base. (320-5)
- Describe the significance of pH in one of the following:

- the maintenance of viable aquatic and/or terrestrial environments
- the body fluids of living systems
- the formation of various products; for example, shampoo, cleaners
(117-2, 117-7, 118-6)

Journal

- Explain how water self-ionizes. Use a diagram to illustrate the proton transfer and the resulting charges on, and structures of, the hydroxide and hydronium ions. (320-5)

Notes

PH Chemistry
Chapter 18.2, 19.2, 19.3

<u>*Core Activities*</u>
Quick Lab – p.604
"Indicators from Natural Sources"

Lab Practical *19-1*
"Acids, Bases, and Salts: Determining pH", Laboratory Manual Reference: Expt. 4

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Using the Equilibrium Concept with Acids and Bases (1)

(7 hours for Using the Equilibrium Concept with Acids and Bases (1), (2), and (3))

NB Prescribed Outcomes

Students will be expected to

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

Elaborations

Students should define strong and weak acids and bases. Students should define % dissociation, Ka and Kb and relate their values to acid and base strength. They should identify the favorability of reactants or products for an acid-base equilibrium based on Ka values provided for reactant and product species.

Students should distinguish between the terms strong acid (or strong base) and acidic (or basic). They should identify the values of pH and pOH associated with acidic and basic solutions.

Students should identify that the presence of $[H_3O^+]$ or $[OH^-]$ from an added strong, or reasonably strong acid or base will not be affected to any significant extent by the self-ionization reaction for water which avoids having to account for the $[H_3O^+]$ or $[OH^-]$ ions produced.

Students should write appropriate Ka and Kb equilibrium constant expression from the equations, knowing that water, as a liquid, is omitted in the equilibrium expression. For example, the acetic acid in vinegar in water:

$$CH_3COOH(aq) + H_2O(l) \rightarrow H_3O^+ (aq) + CH_3COO^- (aq)$$

$$Ka = \frac{[H_3O^+][CH_3COO^-]}{[CH_3COOH]}$$

Students should calculate the value of Ka or an equilibrium concentration given all other values for the equilibrium expression. An ICE (Initial-Change-Equilibrium) chart is a helpful method of organizing data and making the connection between reactant and product species

Teaching Suggestions

Problem solving using Kw might be done here. Students could solve for either $[H_3O^+]$ or $[OH^-]$ using Kw at 25°C. Additional problems could include the determination of the molarity, M, of these ions. For example: calculate the $[H^+]$ or $[H_3O^+]$ if 5.0 g of NaOH is dissolved in 200. mL solution.

.

Using the Equilibrium Concept with Acids and Bases(1) con't

Tasks for Instruction and/or Assessment

Paper and Pencil

- Create a chart illustrating the range of pH and pOH associated with acidic, basic and neutral solutions. Place some common compounds on this scale. For example; pop, battery acid, milk, stomach acid, milk of magnesia, windex, acid rain…(320-3)

- Write the equilibrium constant expression for the following: HClO and CH_3COOH (acids) HS^- and CH_3NH_2 (bases) (320-3)

- The pH of a 0.072 mol/L solution of benzoic acid, $C_6H_5COOH(aq)$ is 2.68. Calculate the numerical value of the Ka for this acid. (320-3)

- What is the pH of a solution formed by mixing 100 mL of 0.150 mol/L HCl *(aq)* with 150 mL of 0.0900 mol/L NaOH *(aq)*? (320-3)

- HF (Ka = 6.6×10^{-4}) and HCN (Ka = 6.2×10^{-10}) are two weak acids that appear in this equilibrium: HCN (*aq*) + F^- (*aq*) $\leftrightarrow$ HF (*aq*) + CN^- (*aq*)

- Use this information to explain qualitatively which equilibrium direction is favoured. Which acts like an acid and which acts like a base?
- Using Ka expressions and the Ka values provided, calculate the numerical value of the equilibrium constant for the reaction. (320-3)

Journal

- Describe the relationship between the Ka value of an acid and the pH of its solution. (320-3)

- Describe why it would it be impractical to include the concentration of H_2O (l) in the acid or base dissociation constant expression. (320-3)

Notes

PH Chemistry
Chapter 19.3
(*for Using Equilibrium Concept with Acids and Bases (1), (2), and (3))*

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Using the Equilibrium Concept with Acids and Bases (2)

NB Prescribed Outcomes

Students will be expected to

- **compare strong and weak acids and bases using the concept of equilibrium (320-3) *(continued)***
- understand that acid and base systems are quantitatively described, using pH, pOH, $[H_3O^+ (aq)]$, $[OH^- (aq)]$, Kw, Ka, Kb, % dissociation, and concentration
- perform calculations to determine any of the above from empirical data
- perform calculations of equilibrium concentrations given initial concentration and K value for which the quadratic equation may be used
- perform calculations of equilibrium concentrations given $[H^+]$ or pH and the K value

.

Elaborations

Teaching Suggestions

For calculations involving the equilibrium constant expression in which calculations must be performed prior to substituting values into the expression, group discussion of problem solving strategies would help students to better understand the relationships between reactant and product species, initially and during equilibrium.

An ICE (Initial-Change-Equilibrium)chart is a helpful method of organizing data and making the connection between reactant and product species.

	CH_3COOH + H_2O	↔	CH_3COO^-	+ H_3O^+
I	0.100M		0	0
C	-x		+ x	+ x
E	0.100-x		x	x

The above ICE table involves the calculation of concentration of all equilibrium species given the Ka and initial concentration. The quadratic equation may be required to solve for –x"; however, the following guide may be used for situations in which the value of Ka (or Kb) is small enough to assume that amount of acid (or base) dissociated, –x", is negligible in relation to the initial concentration of acid (or base). This simplifies the calculation by eliminating the need to use the quadratic equation. i.e. $(0.100-x) \approx 0.100$

If $\frac{[HA]}{Ka} > 500$, the change –x" in initial concentration is negligible.

If $\frac{[HA]}{Ka} < 500$, the change –x" in initial concentration is not negligible. The quadratic equation will be required.

Other methods may also be used to determine if the change in initial concentration is negligible. One method is to assume the change is negligible and use the resulting equilibrium concentrations to calculate the value of Ka (or Kb). If the calculated value is less than 5% different from the given value, the assumption made was acceptable; otherwise, the assumption cannot be made.

Using the Equilibrium Concept with Acids and Bases (2) con't

Tasks for Instruction and/or Assessment

Paper and Pencil

- Calculate the equilibrium concentrations of all species at equilibrium if the pH of a 0.020M solution of C_6H_5COOH is 2.96. (320-3, 320-4)
- Calculate the value of Ka for C_6H_5COOH if the pH of a 0.020M solution of C_6H_5COOH is 2.96. (320-3)
- Calculate the equilibrium concentrations of all species at equilibrium given the following information:

  $[C_6H_5COOH]_{initial}$ = 0.100M; Ka = 6.3×10^{-5}

  $[CH_3COOH]_{initial}$ = 0.100M; Ka = 1.8×10^{-5}

  $[HF]_{initial}$ = 0.100M; Ka = 6.3×10^{-4} (320-3)

Journal

- Explain why in certain situations that an assumption can be made that the difference between the initial and equilibrium concentrations of the reactant species can be considered negligible. (320-3)

Notes

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Using the Equilibrium Concept with Acids and Bases (3)

NB Prescribed Outcomes

Students will be expected to

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

Elaborations
Students should define the pH and pOH of solutions. Students should define the relationships among $[H_3O^+]$, $[OH^-]$, pH, and pOH. Students should perform calculations where they make conversions among these. Solving problems could be practiced in small groups.

Students should calculate $[H_3O^+]$ given the concentration of strong acids. Students should calculate $[OH^-]$ given concentrations of strong bases. Students should calculate the pH or pOH of a diluted solution. Connection should be again made between the dissociation constant and pH where students could calculate the pH of a solution given the initial concentration of a weak acid and Ka.

Students should demonstrate an understand of the various benefits of having a pH scale to represent hydronium ion concentration. The pH scale is the method used to express hydronium ion concentration on labels of consumer products. Concentrations expressed in scientific notation with negative exponents and a range in values in the order of 10^{14} is not appealing to the consumer, and is often not understood.

Teaching Suggestions
In groups of two, students can randomly choose a value for the hydronium ion concentration of a monoprotic strong acid. One student in the group can calculate the pH directly while the other student can calculate the pH indirectly by first calculating the $[OH^-]$ and then pOH. They can then compare results and repeat the activity by reversing roles and choosing another concentration.

Using the Equilibrium Concept with Acids and Bases (3) con't

Tasks for Instruction and/or Assessment

Journal

- How can a pH be negative? (320-4, 212-4)
- Explain why a 0.10 M HCl solution has a low pH. (320-4)
- How does the Ka value of an acid relate to the pH of its solution? (320-4)

Paper and Pencil

- How are acidity and pH related? (320-4)
- What is the pH of a 0.025 M NaOH solution? (320-4)
- The pH of the rain precipitation near a power plant is 4.35. What is the $[OH^-]$ in this precipitation? (320-4)
- What is the pH of a 0.025 M solution of $Ba(OH)_2$? (320-4)
- What is the pH of a 0.02 M benzoic acid solution if $Ka = 6.5 \times 10^{-5}$?. (320-4)

Performance

- Perform an experiment to determine the effect of dilution on the pH of an acid. (320-4)

Notes

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Acid/Base Titrations (1)

(5 hours total for Acid/Base Titration (1) (2) (3))

NB Prescribed Outcomes

Students will be expected to

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

Elaborations

Students should perform stoichiometric titration calculations where one of the following four quantities is to be determined given the other three: molarity of acid; molarity of base; volume of acid; and volume of base. This activity could help with lab questions and stoichiometry problems.

Students should perform a minimum of two titration experiments which may involve: determining an unknown concentration; collecting data to create a titration curve; and determining a value of Ka.

Students' selection of apparatus should be appropriate for use in an acid-base titration. Students might have seen the apparatus that could be used in various titration experiments. Teachers could choose from titration labs such as HCl and NaOH, CH_3COOH and NaOH, or the effectiveness of various antacid tablets. Students should know the terminology involved with titrations: pipette, burette, endpoint, equivalence point, standard solution, and indicator. Students should differentiate between indicator endpoint and equivalence (stoichiometric) point. Planning a lab requires communication and collaboration with the student's lab partner. From teacher information and their own, students should organize the steps that are required in the process for a titration lab.

Reporting of lab results should be done. Students should present their lab results so that their understanding of pH and titrations is clearly shown. Students could use graphs, videos, charts, a computer, activities, or oral reports to consolidate their titration information.

Students should recognize the usefulness of WHMIS standards. Students should be shown the proper use of the equipment. The proper way to handle and dispose of acids and bases is part of WHMIS knowledge that is useful in the laboratory, workplace, and home.

Teaching suggestions

Students could do a project on WHMIS standards. In the lab, students could be shown apparatus that might be used in a future acid base titration experiment and decide on the safe and proper use of the apparatus. Students could be asked to think about how they would safely dispose of acids and bases. Then, information collected could help students know how to use apparatus safely.

Acid/Base Titrations (1) con't

Tasks for Instruction and/or Assessment

Informal Observation / Performance

- Watch the use of the equipment used in an acid-base titration and practise the safe and efficient use of the equipment. (213-8, 2139)
- Design an experiment to test the neutralization effectiveness of various brands of antacid. Show your procedure to your teacher for approval. Include all safety procedures and cautions. Write an advertisement for the antacid you judge to be the most effective. If the experiment is performed, then include data from your experiments in your advertisement. (320-6, 213-8, 215-2, 213-3, 214-5, 215-6, 212-8)
- Show the proper care and maintenance of a burette. (213-8)

Journal

- A NaOH solution has a pH of 10.5. What volume of 0.01 M HCl would be required to titrate this solution to the equivalence point? What additional information is required to solve this problem? (320-6, 215-2, 215-6)
- Explain, qualitatively and quantitatively, the concept of titration. (213-3, 215-2, 320-6)

Paper and Pencil

- Why is a burette used in a titration instead of a graduated cylinder? (213-3)
- A student used 2.00 g of a solid potassium hydrogen sulfate, to titrate with 34.7 mL of a NaOH solution. The molar mass of the acid is 204.2 g/mol. What is the molarity of the NaOH solution? (320-6, 215-6)
- A student titrated 35.0 mL of liquid drain cleaner, containing NaOH, with 50.1 mL of 0.41 M HCl to reach the equivalence point. What is the concentration of the base in the cleaner? Would a computer analysis be helpful here? Explain. (320-6, 215-6)
- Two students want to find the molarity of a lactic acid solution. A 150.0 mL sample of lactic acid, $CH_3CHOHCOOH$, is titrated with 125 mL of 0.75 M NaOH. What is the molarity of the acid sample? (215-6, 320-6, 215-2)
- Examine diagrams of apparatus used in titrations and describe the use of each. Examples should include the burette and Erlenmeyer flask. (213-8, 213-9)

Notes

PH Chemistry
Chapter 19.4

Chemistry 121
Chapter 19.5

Core Activities
PEI Lab
"Acid/Base Titration"

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Acid/Base Titrations (2)

NB Prescribed Outcomes

Students will be expected to

- **explain how acid-base indicators function (320-7)**
  - differentiate between the terms endpoint and equivalence point
  - choose appropriate indicators for acid-base titrations

- **analyse and describe examples where acid-base understanding was enhanced as a result of using titration curves (116-2)**
  - qualitatively sketch and interpret titration curves

Elaborations

Students should compare the qualitative term, endpoint, with the quantitative term, equivalence point. Students should identify the pH of a solution using indicators. Students should choose appropriate acid-base indicators given the pH at the equivalence point and a table of effective pH ranges for various acid-base indicators.

Students should explain the results of a titration graph involving a polyprotic species with a strong base (for example, phosphoric acid with sodium hydroxide). Students should explain the pH at the equivalence point when strong acids are mixed with weak bases and vice versa. Teachers might mention salt hydrolysis here to help explain titration curves, in particular when the pH at the equivalence point does not equal 7.

Teaching suggestions

Students could perform an experiment to determine the pH of various acids and bases using indicators.

Students could explain a titration graph involving a polybasic species with a strong acid (for example, hydrochloric acid, a strong acid with sodium carbonate).

Acid/Base Titrations (2) con't

Tasks for Instruction and/or Assessment

Performance

- Your teacher will give you a solution to test for pH using indicators. Describe exactly how you would test the solution. Show your plan to your teacher. If approved, conduct the test and report the results. (213-8, 215-2, 213-3, 214-5, 215-6, 212-8, 320-7)

Paper and Pencil

- How is the colour change of an indicator related to pH? (320-7)
- What is key in choosing an appropriate indicator? (320-7, 116-2)
- What indicators could you use for a titration involving a solution of HCl, a strong acid, and a solution of Na_2CO_3, a weak base? (320-7, 116-2)
- What is equivalence point? endpoint? Why is it important that both occur at approximately the same pH in a titration? (320-7, 116-2)
- If a titration between a weak acid and a strong base has an equivalence point pH of 9.5, which indicators could be used to detect the equivalence point of the titration? (320-7, 116-2)
- What is the determining factor when selecting an indicator to use in a titration? (320-7, 116-2)
- For the following titrations, select the best indicator from these choices: bromophenol blue, bromothymol blue, phenol red.

- HCOOH, formic acid, with NaOH
- HCl with potassium hydroxide
- ammonia with hydrochloric acid
(116-2, 320-7)

- Which indicators would work best for a titration with

- an endpoint at a pH of 4.0?
- a weak base with a strong acid?
Use an indicator chart as a reference. Justify your choice. (116-2, 320-7)

Journal

- In the titration of a weak acid with a strong base, explain if the pH at the equivalence point is greater than, less than, or equal to 7. (116-2, 215-2)
- Why is it best to titrate with a dilute solution? (116-2, 320-7)

Notes

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Acid/Base Titrations (3)

NB Prescribed Outcomes

Students will be expected to

- **identify a line/curve of best fit on a scatter plot and interpolate and extrapolate based on the line of best fit (214-4)**
  - interpret, interpolate and extrapolate data from a titration curve
  - graph sample data collected from a titration experiment or data provided by their teacher

- **state a prediction and hypothesis based on available evidence and background information (212-4)**

Chemistry 121

- Demonstrate the use of buffers in chemical systems especially in biological systems (eg. blood)

Elaborations
Students should interpret, interpolate and extrapolate data from a titration curve of an acid-base neutralization reaction.

Using various examples, students should predict acid-base strength of various foods based on their knowledge.

Teaching suggestions
Students could graph sample data collected from one of the titration experiments or data provided by their teacher. This provides an opportunity to use current software and technology to identify the pH value at which the equivalence point is reached. Viewing several graphs at once will allow students to observe and develop an understanding of the significance of the shape of the curve in relation to the strength of the acid and base titrated.

Students could look at various foods or liquids to predict the strength of the acid in these products. Some substances might be milk, red cabbage, coffee, pop, apple juice, and liquid soap. Students might prepare a chart to show their predictions, and, later, they could find the pH and compare their predictions with actual results.

Predict whether substance is acidic or basic

Substance	Prediction	Strength	pH Value
milk	basic	low	6.6
red cabbage			

Acid/Base Titrations (3) con't

Tasks for Instruction and/or Assessment

Performance

- Create a poster illustrating both proper and improper acid-base disposal. (213-9)
- Predict and test the pH of various foods. Use the operational definitions you had created at the beginning of this unit to predict the pH and use pH paper or indicators to test pH levels. Record your predictions and results in a chart. (212-4)

Paper and Pencil

- Collect data from an acid-base titration experiment and plot a curve of pH vs[ ]. (214-4)
- Interpret the data from an acid-base curve by identifying: the equivalence point; pH at the equivalence point; the nature of the acid and base species (strong or weak). (214-4, 212-4)

Notes

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Unit 4 - Organic Chemistry

(24 hours)

Introduction

In this unit, the bonding capacity of carbon, hydrogen, oxygen, nitrogen, and the halogens will be reviewed, as will the potential for these atoms to form covalent compounds. The vastness of the number of organic molecules will be explored using isomers and polymers as examples. With so many different organic molecules to consider, the students will come to appreciate the need for a systematic naming scheme. The students will be given opportunities to discover how the classification of organic molecules into different family groups depends upon the type of bonding and atoms present. The students will also examine how these factors influence the reactivity of representative molecules from each of the different families. Organic chemistry is the study of molecular compounds of carbon.

Focus and Context

Humans and all living organisms are made up of molecules that contain carbon. Carbon provides the backbone for many molecules essential for life. Deoxyribonucleic acids (DNA), proteins, carbohydrates, cellulose, fats, and petroleum products all contain organic molecules. Having the students consider the chemistry that exists within their own bodies can make the study of organic molecules more relevant and interesting. By studying the impact of technological applications of organic chemistry on the world around them, students will develop an appreciation for the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology. Using a context such as the problem of ozone depletion provides students with an opportunity for attitudinal growth. Furthermore, students should develop a sense of personal and shared responsibility for maintaining a sustainable environment. Ultimately, students should be aware of the direct and indirect consequences of their actions. Other contexts could work just as well.

Science Curriculum Links

Organic chemistry provides an opportunity to review outcomes in the From Structures to Properties unit. The organic unit will allow the students to reinforce their understanding of valence electrons, chemical bonding, and intermolecular and intramolecular forces.

This unit reinforces and expands upon the study of natural and synthetic compounds containing carbon that was introduced in science 10. As well, the grade 9 science program introduced students to the chemistry of petrochemicals. Petrochemicals form the basis of the chemistry 12 thermochemistry unit.

Pan-Canadian Specific Curriculum Outcomes

STSE

Students will be expected to:

Nature of Science and Technology
114-4 identify various constraints that result in trade-offs during the development and improvement of technologies

115-1 distinguish between scientific questions and technological problems

115-3 explain how a major scientific milestone revolutionized thinking in the scientific communities

115-6 explain how scientific knowledge evolves as new evidence comes to light

Relationship Between Science and Technology
116-6 describe and evaluate the design of technological solutions and the way they function using scientific principles

116-7 analyse natural and technological systems to interpret and explain their structure and dynamics

Social and Environmental Contexts of Science and Technology
117-4 debate the merits of funding specific scientific or technological endeavours and not others

117-5 provide examples of how science and technology are an integral part of their lives and their community

118-2 analyse from a variety of perspectives the risks and benefits to society and the environment of applying scientific knowledge or introducing a particular technology

118-4 evaluate the design of a technology and the way it functions, on the basis of a variety of criteria that they have identified themselves

Skills

Students will be expected to:

Initiating and Planning
212-2 define and delimit problems to facilitate investigation

212-3 design an experiment identifying and controlling major variables

Performing and Recording
213-7 select and integrate information from various print and electronic sources or from several parts of the same source

213-8 select and use apparatus and material safely

Analysing and Interpreting
214-2 identify limitations of a given classification system and identify alternative ways of classifying to accommodate anomalies

214-9 identify and apply criteria, including the presence of bias, for evaluating evidence and sources of information

214-11 provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion

214-17 identify new questions or problems that arise from what was learned

Communication and Teamwork
215-1 communicate questions, ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others

215-3 synthesize information from multiple sources or from complex and lengthy texts and make inferences based on this information

215-5 develop, present, and defend a position or course of action, based on findings

Knowledge

Students will be expected to:

319-3 illustrate, using chemical formulas, a wide variety of natural and synthetic compounds that contain carbon

319-4 explain the large number and diversity of organic compounds with reference to the unique nature of the carbon atom

319-5 write the formula and provide the IUPAC name for a variety of organic compounds

319-6 define isomers and illustrate the structural formulas for a variety of organic isomers

319-7 classify various organic compounds by determining to which families they belong, based on their names or structures

319-8 write and balance chemical equations to predict the reactions of selected organic compounds

319-9 describe processes of polymerization and identify some important natural and synthetic polymers

So Many Compounds

(3 hours)

NB Prescribed Outcomes

Students will be expected to

- **explain the large number and diversity of organic compounds with reference to the unique nature of the carbon atom (319-4)**
- compare organic and inorganic compounds in terms of the presence of carbon, variety of compounds formed, and relative molecular size and mass
- develop an understanding of the historical significance of the name organic chemistry
- list natural sources of organic compounds
- represent hydrocarbons using: molecular formula, expanded molecular formula, complete structural diagram, condensed structural diagram, line structural diagram

Elaborations

To develop an appreciation for the scope of organic chemistry, students could brainstorm to compile a list of different molecules they have heard about from biology courses, food sources, pesticides, petroleum products, pharmaceuticals, and other everyday sources. Of the millions of compounds known to humans, the vast majority are molecular compounds of carbon. Students should try to explain this diversity of organic compounds.

Once the students compile an array of the molecules they have found, they should be asked to determine which of these come from living organisms and which are artificial or synthesized by humans. From this activity, the students should realize that many organic molecules are derived from living sources and should understand the historical significance of the name ―Organic Chemistry."

Students should describe carbon's bonding capacity and carbon's ability to form multiple bonds and to bond in a variety of stable structures. Students should identify the geometry of carbon compounds, the strong bonds between carbon atoms, and the low reactivity of carbon compounds.

Students should consider what makes carbon compounds different from other compounds. Because students have studied some bonding, organic chemistry offers an opportunity for students to explore the spatial characteristics of simple organic compounds. Students should use model kits to investigate the symmetry of simple organic compounds.

Teaching suggestions

By relating organic compounds to students' lives this topic will be more relevant and motivating. Some examples that might be used are fat-free potato chips, acrylamide, or a cure for cancer.

The students could be asked to search reference materials, such as a chemistry handbook (example: Merck Index, Handbook of Chemistry and Physics, Chemical Dictionary) and/or the Internet, to try to discover the structural formulas of these different compounds. They could find molecules that contain carbon and look at relative molecular size and mass of the molecules.

The ―Risks and Benefits of Organic Compounds" section located at the end of this unit could be introduced here to give students an overview of the unit. Throughout this unit, the research project could be mentioned. An alternative suggestion to address the outcomes would be for students, in groups of two, to develop an STSE question based on a controversial compound.

The nature of methane's tetrahedron or the ends of ethane rotating could be examined with the model kits. Students might compare properties of C_4H_{10} with Si_4H_{10} or CCl_4 with $SiCl_4$. Students might look at the structures of graphite and diamond to demonstrate the layering of hexagons and the strength of a tetrahedron.

So Many Compounds con't

Tasks for Instruction and/or Assessment

Journal

- Carbon bonding is important in organic compounds. Explain why. (319-4)
- Are all carbon compounds organic compounds? Explain. (319-4)
- http://www.chm.bris.ac.uk/motm/motm.htm, provides some interesting organic compounds at a site called Molecule of the Month.

Paper and Pencil

- Make a chart to list the compounds you found and the elements contained in the compounds according to the following groupings: C and H only; C, H, and O only; C, H, and N only; C, H, and halogens only; and others. (319-4)
- Can three-dimensional aspects of structure be communicated easily on paper? If so, how? (319-3, 319-4)
- Suggest a reason why graphite is more chemically reactive than diamond. (319-4)

Performance

- Using the models, make structures of 10 of the carbon molecules you found. (319-3, 319-4)
- Draw Lewis structures of five of the carbon molecules you found. (319-4)
- Select an organic substance from the ingredient list on the packaging of a food item. Research the structure of the organic substance. (319-4)
- Perform an experiment involving the construction of molecular models for various organic compounds. (319-4)

Presentation

- Your teacher will give you a large index card on which to write one compound's formula or structure and its name. Put yours on the bulletin board to be viewed by your classmates. (319-4)
- Develop a class time line across one wall of the room of the dates various organic compounds were discovered or developed. Add a compound with the following information: the chemical formula, when it was developed, and one or two interesting facts about it, such as its use and if it was ever banned. (319-4)

Notes

PH Chemistry
Chapter 22.1

Core Activities
Conceptual Problem 22.2 – p. 699
"Naming Branched-Chain Alkanes"

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Influences of Organic Compounds on Society

(1 hour)

NB Prescribed Outcomes

Students will be expected to

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

Elaborations

Students should look at an organic compound's influence on society– whether it is a natural or technological substance.

Students should distinguish between science and technology questions and problems that deal with applications of organic chemistry. Students might distinguish between questions such as ―How are PCBs converted into dioxins?" and technological problems such as ―How can we dispose of PCB laden oils?

Students should consider the significance of being able to synthesize organic molecules, the fact that this was not always possible, and that these molecules can be both helpful and harmful.

Teaching Suggestions

A class discussion about synthesized organic molecules could be initiated. Questions might be designed to help the students brainstorm their ideas, and/or students might use a flow chart, diagrams, or computer software. Many synthesized organic molecules are originally extracted from living sources and this might provide an interesting context for discussion. Students could debate the advantages and disadvantages of synthesizing molecules.

For example, acetylsalicylic acid, or aspirin, can be derived from the white willow tree but is now produced almost exclusively in a laboratory. The financial and environmental benefits related to the synthesis of TAXOL™ from 1 0-deacetlybaccatin III may be explored.

Another beneficial example is the synthesis of the molecule insulin, which is needed in the treatment of diabetes. Since insulin had previously been isolated from the pancreas of cows and pigs, the discovery of a method to produce it artificially was a welcome innovation.

On the other hand, the ability to manufacture molecules has caused the production of CFCs, which are currently destroying the ozone layer. Students could be provided with the opportunity to consider the factors surrounding the ozone debate.

Students could research substances such as Thalidomide and replacement drugs. Students might suggest whether or not the use of Freon and leaded gasoline should be encouraged in developing countries

Influences of Organic Compounds on Society con't

Tasks for Instruction and/or Assessment

Informal Observation

- Create an observation criteria with your teacher to consider the synthesizing of organic molecules from a number of different perspectives and to weigh conflicting information. Think about and articulate the kinds of knowledge, skills, and attitudes needed to analyse and critique this major scientific issue. (115-3, 115-6)

Journal

- What are the societal implications of the use of organic chemicals to control pests in agricultural chemistry? (114-4, 117-5)
- How are open-mindedness, critical thinking, and decision-making skills necessary for deciding how science and technology relate to organic compounds and your life? (116-7, 117-5)

Paper and Pencil

- Investigate the technology of designing new synthetic schemes to prepare important organic compounds. Report your findings in a brochure, newspaper article, or memo. (114-4, 115-3, 117-5, 118-4)
- CFCs are unique in that they have no natural source. Discuss the history of CFC production, useful qualities, absorption in the atmosphere, and questions that need to be addressed to draw conclusions. (116-7, 115-3, 115-6, 114-4, 117-5)
- Generate your own example of a scientific question or technological problem on an application of organic chemistry. Trade with another student and suggest an answer to his/her question or problem. (115-1)
- Address the problem of ozone depletion. This is not a problem with a single correct solution, but once evidence is assessed, decisions must be made and measures taken. With evidence, describe a possible solution. (116-7)
- Research and report on Canadian Raymond Lemieux and the synthesis of sucrose. (116-7)

Presentation

- Debate the advantages and disadvantages of synthesizing molecules. (115-3, 115-6)
- Debate the power of synthetic chemistry versus the use of naturally occurring limited resources. (115-3, 114-4, 117-5)

Performance

- Debate the pros and cons of being able to manufacture organic molecules. Debate or assume roles that scientists play in changing the directions of chemical research. Friedrich Wöhler may be one scientist to refer to. (116-7)

Notes

PH Chemistry
Chapter 22.1, 22.5

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Classifying Organic Compounds

(2 hours)

NB Prescribed Outcomes

Students will be expected to

- **classify various organic compounds by determining to which families they belong, based on their names or structures (319-7)**
- classify aliphatic hydrocarbons as belonging to the family of alkanes, alkenes, alkynes, and cyclics based on their names and structural formulas.
- classify aromatic hydrocarbons as compounds that have a benzene ring as part of their structure.
- define ~~"~~functional group"
- classify hydrocarbon derivatives as belonging to the family of alkyl halides, alcohols, carboxylic acids, and esters from their names and the functional groups in their structural formulas.
- draw bonds and use molecular models to represent aliphatic and aromatic hydrocarbons, and hydrocarbon derivatives.

Chemistry 121

- include ethers, aldehydes, ketones, amines and amides.

Elaborations

Students should classify compounds as aliphatic hydrocarbons, aromatic hydrocarbon and hydrocarbon derivatives. One strategy would be to start with a basic overview of these three broad categories and then proceed with the components of each individual category sequentially as the topic arises with regard to recognition of the family based on name and structure, and naming and drawing structures of component within the family.

If teachers have spent adequate time on the electronics and typical bonding of carbon, hydrogen, halogens, and oxygen, classification should be easier for students. Students' general spatial awareness and understanding of chemical bonds might be developed by using model kits.

Teaching suggestions

Students could rotate through the following organic compound centres/stations described in this section: a) composition of hydrocarbons and derivatives, b) bonding and electron dot diagrams, c) molecular model activities, d) benzene and relatives, e) paper and pencil activities, f) defining and identifying functional groups, and g) computer activities. Teachers could develop each centre so that it could be checked by the student and verified by the teacher to ensure that there is a plan to follow. Because of the different learning styles that students have, a variety of classification activities helps all students learn.

Students could look at the composition of hydrocarbons and derivatives through a classification activity based on names and structures. Teachers might refresh students' skills on classification by doing a simple activity such as classifying buttons or keys. From this, students could be provided an opportunity to recognize the need for classification schemes and given time to devise their own scheme.

Students could work in groups whose task is to organize into categories cards that contain the structures of alkanes, alkenes, alkynes, cyclic hydrocarbons, aromatic hydrocarbons, and hydrocarbon derivatives. Students could compare the structures on the cards and group them into six different groups according to their similarities.

Students could do an activity that looks at organic compounds and bonding and then draw electron dot diagrams. These diagrams could show the bonding in alkanes, alkenes, alkynes, cyclic hydrocarbons, aromatic hydrocarbons, and hydrocarbon derivatives.

Students could use molecular models for the same groups as the bonding activity. Students could draw bonds and use molecular models for hydrocarbons and their derivatives.

Classifying Organic Compounds con’t

Teaching Suggestions con’t

In the benzene and relatives centre, molecular kits could be provided so students could make three dimensional models of the structures and examine bond angles and shape. Students could build and describe the bonding in benzene. Benzene’s unreactive nature and equal C-C bond lengths are evidence that benzene has delocalized electrons and does not have alternating single and double bonds. Students could define aromatics as compounds that have a benzene ring as part of their structure and, given their names, draw structures for simple monosubstituted and disubstituted benzenes.

The centre of paper and pencil activities could include exercises, diagrams, formulas, names, and charts about hydrocarbons, hydrocarbon derivatives, aromatics, and functional group names and structures. This centre might be done in stages throughout the other centres because it includes all families, names, and structures. Students should identify organic halides, alcohols, ethers, aldehydes, ketones, carboxylic acids, organic halides, and esters from their names and the functional groups in their structural formulas. Planning this centre using a variety of formats from models, card classification, bonding, and charts keeps students learning by doing as opposed to memorization.

Students might need this overview because of their different learning styles.

Computer activities could include completing a webquest, working on various organic sites, and/or doing a multimedia presentation of information on classification of organic compounds.

Teachers or students could prepare a set of playing cards for groups of four students to use for classifying organic compounds. Sets of cards that contain the structural formulas of a variety of organic molecules from different families and the organic halides could be provided for the students to use as a reference. Students could use these cards to play games such as concentration or fish. Since the cards provide samples of different molecules within the same class, students should recognize a need for a systematic naming scheme. This activity uses reasoning skills and patterns to help with classification and students feel in charge of their learning.

Teachers should help students consolidate their knowledge by a class overview of the organic compounds once students have worked through the centres

Classifying Organic Compounds con't

Tasks for Instruction and/or Assessment

Journal

- Explain why triple bonds are more difficult to break than single bonds. (319-7)
- Explain why the reaction takes place at the site of the triple bonds in alkynes. (319-7)
- Aldehydes and ketones contain the same functional group. What makes them different? (319-7)

Paper and Pencil

- Draw electron dot diagrams for seven compounds that you randomly draw from the deck of cards on alkanes, alkenes, alkynes, cycloalkanes, aromatics, and organic halides. (319-7)
- Make a chart of the classes of organic compounds. Fill it in with the class, functional group, and an example. (319-7)
- Make a chart to compare different classes of organic compounds based on the same prefix. For example, your compounds might be propane, 1 -propanol, propanoic acid, propanone, and dimethyl ether. The chart should include the formula, melting point, boiling point, and density. (319-7)
- What is an alkane? an alkene? an alkyne? (319-7)
- Draw the different representations of benzene. (319-7)
- How are organic compounds classified? (319-7)
- List elements that can bond to carbon in organic compounds. (319-7)
- Make a record of the foods you eat in one day. Compare the content labels from the foods and list the chemicals in them. Classify the organic chemicals by their functional group. (319-7)

Presentation

- At lab stations, make compounds from model kits and identify the family. (319-7)
- Design and make models for a number of hydrocarbon molecules using different materials. (319-7)

Notes

PH Chemistry
Chapter 22.2, 22.4

Check NB Government Portal for current links and shared resources https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Naming and Writing Organic Compounds (1)

(5 hours for Naming and Writing Organic Compounds (1) and (2))

NB Prescribed Outcomes

Students will be expected to

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

Elaborations

Considering the massive number of possible hydrocarbon molecules to examine, the following guidelines address the depth of this outcome.

Students should be expected to work with:

– aliphatic hydrocarbons with a maximum of ten carbons in the parent chain and a chain containing maximum of one double or triple bond.

– substituents on the parent chain should be restricted to halogens, phenyl, and alkyl groups with a maximum of 10 carbons and no branching of the alkyl stem.

Students should write the general formulas for aliphatic hydrocarbons (C_nH_{2n+2} , C_nH_{2n} , C_nH_{2n-2}, etc..) for alkanes, alkenes, alkynes, cycloalkanes, and cycloalkenes

Teaching suggestions

This section should be easier for students to learn once they have done the centres described in the Classifying Organic Compounds section.

In pairs, students could construct models of aliphatic and aromatic hydrocarbons and challenge their partners to name and draw the structure. Similarly, teachers could have each student create a molecular model and have the resulting structures organized in a particular area (model stations) within the classroom. Each student could then examine the molecular models and record the corresponding names and structural formulas for each model.

Naming and Writing Organic Compounds (1) con't

Tasks for Instruction and/or Assessment

Performance

- Design and present a flow chart, poem, story, or song to summarize the IUPAC rules for naming and writing aliphatic and aromatic organic compounds. (319-5)

Paper and Pencil

- Name the following straight-chain alkanes: $C_{10}H_{22}$,C_3H_8 , C_8H_{18} , C_4H_{10}. (319-5)
- Draw the structure of C_5H_{10}. Classify it. Explain your choice. (319-5a)
- What is the chemical formula of an alkyne with 15 carbons? (319-5a)
- Compare structural formulas with chemical formulas. Are there any advantages for either? (319-5)
- Why do dieticians tell us unsaturated fatty acids are a better choice than saturated fatty acids? (319-5)
- List the rules for assigning numbers to carbon atoms. (319-5)

Notes

PH Chemistry
Chapter 22.1, 22.4, 23.1, 23.2, 23.3
(for Naming and Writing Organic Compounds (1) and (2))

Core Activities
Lab Manual – *Lab 49, p.291*
"Hydrocarbons: A Structural Study"

PEI Lab
"Organic Compounds 1: Structure and Nomenclature of Organic Compounds"

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Naming and Writing Organic Compounds (2)

NB Prescribed Outcomes

Students will be expected to

- **write the formula and provide the IUPAC name for a variety of organic compounds (319-5)**

- use the IUPAC naming system, write molecular formulas, and draw structural formulas, condensed structural formulas, and line structural formulas for hydrocarbon derivatives belonging to the family of alkyl halides, alcohols, , carboxylic acids, and esters limited to only one functional group and a parent chain no longer than 10 carbons.

- **identify limitations of the IUPAC classification system and identify alternative ways of classifying to accommodate anomalies (214-2)**

Chemistry 121

- Use IUPAC rules for naming ethers, aldehydes, ketones, amines and amides

Elaboration

Considering the massive number of possible hydrocarbon derivatives to examine, the following guidelines address the depth of this outcome. Students should be expected to work with:

– hydrocarbon derivatives with only one functional group (exception: alkyl halides can be multi-substituted) and with a parent chain containing a maximum of ten carbons.

– hydrocarbon derivatives which contain halogens or oxygen containing functional groups belonging to the family of alkyl halides, alcohols, ethers, aldehydes, ketones, carboxylic acids, and esters

– substituents on the parent chain should be restricted to halogens, phenyl, and alkyl groups with a maximum of 10 carbons and no branching of the alkyl stem.

Students should identify IUPAC and non-IUPAC names for the same substance. Teachers could provide examples of common organic compounds for the students to observe. A discussion about the uses of the IUPAC name and common name might help the students understand how classifying could vary. Students could identify examples of the persistence of non-IUPAC names for consumer products, common chemicals such as ―acetone," and ―acetic acid", or for macromolecules where the IUPAC name is extensive.

Teaching Suggestions

Teachers could introduce this section with cards that contained structures of alcohols, ethers, aldehydes, ketones, carboxylic acids, and esters. Students should recognize that the presence of oxygen and its bonding arrangement with carbon and hydrogen influences the family to which the compound belongs. Familiar compounds such as ethanol, formaldehyde (methanal), acetic acid (ethanoic acid) and diethyl ether (ethoxyethane) could be discussed. Students could look at the properties of these substances and gain an appreciation of the diversity and use of organic molecules.

Naming and Writing Organic Compounds (2) con't

Tasks for Instruction and/or Assessment

Performance

- Design and present a flow chart, poem, story, or song to summarize the IUPAC rules for naming and writing formulas for hydrocarbon derivatives. (319-5)

Paper and Pencil

- Identify the compound and define the functional group from compound models made from the kit. (319-5)
- Draw complete structural diagrams that show the difference between 1-propanol and dimethyl ether. (319-5)
- Compare structural formulas with chemical formulas. Are there any advantages for either? (319-5)
- Draw structural formulas and give the molecular formulas for 2-pentanone, a solvent; butanoic acid, a component of butter; and chloroethene, used in plastics. (319-5)
- Why do the name of aldehydes or organic acids not always contain numbers indicating the position of the aldehyde and acid groups? (319-5)
- List the rules for assigning numbers to carbon atoms in molecules containing each type of functional group. (319-5)

Notes

Check NB Government Portal for current links and shared resources https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Isomers in Organic Chemistry

(2 hours)

NB Prescribed Outcomes

Students will be expected to

- **define isomers and illustrate the structural formulas for a variety of organic isomers (319-6)**
  - define isomer, structural isomer, and geometric isomer
  - explore isomers by drawing structural formulas, using models to build isomers, and naming the isomers of a variety of organic molecules
  - draw structural isomers of hydrocarbons with the general formulas C_nH_{2n+2} , C_nH_{2n} , and C_nH_{2n-2}
  - draw geometric isomers (cis and trans) for alkenes

Chemistry 121

- Identify optical isomers. Discuss their importance in biological systems.

Elaborations

Students should have the opportunity to explore isomers by drawing structural formulas, using models to build isomers, and naming the isomers of a variety of organic molecules. Students should define and give examples of structural isomerism. Students should be able to draw structural isomers of hydrocarbons with the general formulas C_nH_{2n+2}, C_nH_{2n}, and C_nH_{2n-2}

Students should be exposed to various models of isomers from the same chemical formula. Models described on an overhead transparency for this would show the class the structures and initiate discussion. From this, students could practise drawing and naming isomers.

Students should be able to draw geometric isomers (cis and trans) for alkenes. Opportunity should be provided for the students to draw, model, and name the isomers of a variety of organic molecules.

Teaching Suggestions

Through an activity, students could gain practice in forming the models and drawing the models to indicate their three-dimensional structure. Students could look at various structures to see whether isomerism has an effect on the properties of the substance. If the students have actually considered the effect that isomerism has on the properties of alcohols from the lab on their boiling points, they should be able to extend this understanding to isomers of other organic families.

Isomers in Organic Chemistry con't

Tasks for Instruction and/or Assessment

Journal

- You have two structural formulas, but each has the same chemical formula. What differences in the properties of each are a result of the structure? (319-6)

Paper and Pencil

- Draw two structural formulas for an alcohol with the molecular formula C_4H_9OH. (319-6)
- Draw structural isomers for butane and for butene. (319-6)
- Using the molecular formula C_3H_8O, draw one structural formula for an alcohol and one for an ether. Name each one. (319-9)
- Draw and name all isomers (structural and geometric) with molecular formula C_5H_{10} (319-6)
- Why is it important to NOT label a flask as $C_4H_{10?}$ (319-6)

Notes

PH Chemistry
Chapter 22.3

Core Activities
Quick Lab – p.707
"Structural Isomers of Heptane"

Small Scale Lab – p.708
"Hydrocarbon Isomers"

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Applications of Organic Chemistry (1)

(2 hours for Applications of Organic Chemistry (1) and (2))

NB Prescribed Outcomes

Students will be expected to

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

Elaborations

Students should describe carbon's unique bonding capability and how this is the basis of organic chemistry. From boiling point data, students should explain trends in boiling point in relation to the number of carbons in, and branching of, the hydrocarbon chain.

Students should be exposed to today's world of rapid technological development in which the concepts of organic chemistry are being applied to everything. Students could analyse the numerous steps involved in the refining of petroleum to obtain gasoline and a variety of other products. Students might look at technologies that allow us to produce organic chemicals and the societal implications of the science and technology.

Students should describe, in general, the process of cracking and reforming to create specific molecules of smaller and larger molar mass, respectively. Student should discuss how science and technology contribute to the production of more commercially viable products.

Teaching suggestions

If time permits, students might examine the effect structure has on the boiling points of several alcohols in a simple laboratory experiment and thus discover the existence of isomers.

In planning for this experiment the students should examine Material Safety Data Sheets (MSDS) for the alcohols involved and outline safe laboratory procedures. Of primary concern is the flammability of the alcohols. Alcohols of progressively higher molecular mass could be used, but attempts could be made to include at least a couple of sets of isomers. For example, isopropyl alcohol and n-propyl alcohol are readily available. Tert-amyl and n-amyl alcohols are another possibility.

For each alcohol, the students could determine the molecular and structural formulas. After finding the boiling points of the alcohols, students could address questions such as the following:

- What effect did a branching the length of the hydrocarbon chain have on the results?
- Using what you know about intermolecular forces explain these results.
- Explain any trend in boiling points.

Applications of Organic Chemistry (1) con't

Tasks for Instruction and/or Assessment

Performance

- In group discussions after your lab on alcohols, address the following questions:
  - Could this same experiment have been done with alkanes of similar molecular mass?
  - Using what you know about intermolecular forces, explain why or why not. (214-11)

Paper and Pencil

- Explain the process of fractional distillation? (117-5)
- What is LNG? Explain the current interest in LNG and the possible environmental impact of its use, production and transport.
- What determines the location (height) at which a chemical condenses in a fractional distillation tower? (214-11, 117-5)
- Explain the benefits of cracking and reforming. Write chemical equations to support your answer. (214-11)
- Methane gas is sometimes referred to as marsh gas. Discuss this. (214-17)

Notes

PH Chemistry
Chapter 22.5 *(for Applications of Organic Chemistry (1) and (2))*

Core Activities
Lab Manual *– Lab 50, p.299*
"Esters of Carboxylic Acids"

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Applications of Organic Chemistry (2)

NB Prescribed Outcomes

Students will be expected to

- **identify various constraints that result in trade-offs during the development and improvement of technologies (114-4)**
- **evaluate the design of a technology and the way it functions, on the basis of a variety of criteria that they have identified themselves (118-4)**
- **identify and apply criteria, including the presence of bias, for evaluating evidence and sources of information on an organic topic (214-9)**

Elaborations

Students should give the pros and cons that resulted from the technology developed to synthesize, extract, or separate organic compounds.

Students should evaluate information and give their opinions based on evidence from an article on an organic topic. This article might be one they have found in the media or on the Internet or through STSE questions

Teaching suggestions

Students could explore examples of organic compounds used in their daily lives, such as the banning of lead gasoline because of its impact on the environment which resulted in consumers using unleaded gasoline. Students could identify such constraints as cost and care for the environment when deciding on the degree to which petroleum will be refined. Examples of organic compounds and the relationship of these compounds to students' lives and their community help them understand the influence science and technology have on society.

Students could evaluate various environmental aspects of the impact of organic chemistry. Topics that might be used include the advertisements for ethanol-blended gasoline, the environmental impact of various refrigerants, and the function of a herbicide that is not toxic to humans and does not accumulate in the environment.

For students to evaluate information and give their opinions based on evidence from an article on an organic topic, they could work in groups. With two to four students, criteria might be set to determine whether the evidence and the sources of information are reliable, unbiased, clearly explained, and specific. Students could find provincial regulations governing the emission outputs of vehicles. Students might continue their STSE assignment by preparing articles and questions about organic chemistry topics that might be controversial but useful.

Applications of Organic Chemistry (2) con't

Tasks for Instruction and/or Assessment

Paper and Pencil

- Explain the environmental and economical benefits of cracking and reforming. (114-4)
- Identify the pros and cons of banning the use of leaded gasoline and replacing it with unleaded. (114-4, 214-9)
- Evaluate the environmental impact of a herbicide on food production. Identify and evaluate the criteria that you select. (118-4, 214-9)

Notes

Check NB Government Portal for current links and shared resources [*https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx*](https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx)

Writing and Balancing Chemical Equations

(4 hours)

NB Prescribed Outcomes

Students will be expected to

- **write and balance chemical equations to predict the reactions of selected organic compounds .(319-8)**
- draw structural diagrams of all organic reactants and products involved in:
  - i. addition (alkenes & alkynes)
  - ii. substitution (alkanes & benzene)\
  - iii. esterification
  - iv. complete combustion
  - v. cracking/reforming reactions
  - vi. predict the relative reactivity of alkanes, alkenes, and alkynes

Chemistry 121

- **write and balance chemical equations to predict the reactions of selected organic compounds. (319-8)**
- draw structural diagrams of all organic reactants and products involved in:
  - i. incomplete combustion
  - ii. elimination reactions

Elaborations

Students should know that: alkanes and benzenes can undergo substitution; alkenes and alkynes can undergo addition; alcohols and acids condense to form esters via esterification. The students sould predict what the products will be for these reactions and for complete and incomplete combustion as well. Students should draw structural diagrams of all organic reactants and products in addition, substitution, esterification, complete and incomplete combustion, and cracking/reforming reactions. Due to the difficulty in predicting the products of cracking and reforming reaction, sufficient information should be provided to allow the students to be able to make a prediction.

For example, a student should determine the name and structure of a missing reactant (or product) given an organic reaction with one reactant (or product) missing. This method can also be used for other reaction types.

Teaching Suggestions

Examples such as photosynthesis and cellular respiration might be used to introduce this outcome. In discussing the typical reactions, concepts such as electronegativity, charge, dipoles, and polar covalent and nonpolar covalent bonds could be used to understand why the functional groups determine the reactivity of an organic molecule. Some functional groups to study include hydroxyl and carboxyl. Students could be asked to predict the relative reactivity of alkanes, alkenes, and alkynes. This type of understanding allow students to go beyond the rote learning approach.

Students can create a list or organizational chart of reaction types and identify the family of compounds or functional groups that undergo these specific types of reactions. An alternate approach could involve listing the family of compounds and identifying the types of reactions that commonly occur within the family. For example: Alkanes undergo substitution reactions with halogens; Alkenes and Alkynes undergo addition reactions with halogens, hydrogen, hydrogen halides, and water.

Writing and Balancing Chemical Equations con’t

Tasks for Instruction and/or Assessment

Paper and pencil

- Write a balanced chemical equation for the addition reaction involving hydrogen bromide and ethene. (319-8)
- Write a balanced chemical equation for the complete combustion of C_4H_{10}. (319-8)
- Write a balanced chemical equation for the substitution reaction involving one molecule of methane and one molecule of chlorine. (319-8)
- Write a balanced chemical equation for the addition of H_2, H_2O, HCl, and Cl_2 to propene. Include all possible isomers. (319-8)
- How many ester products can be synthesized from the following reactants: ethanol, propanol, ethanoic acid, and butanoic acid? For each reaction, write a balanced chemical equation containing the structural formulas and provide the name of the ester products. (319-8)

Presentation

- Interview a person, in person or via e-mail, whose occupation involves organic chemistry. Determine the organic chemical reaction(s) involved in their occupation and talk about the equation. (319-8)
- Discuss, in small groups, the following problems that face a research or industrial chemist:
- How are products recognized and isolated?
- How are yields optimized?
- What is the potential for isomeric products, and is it possible to increase the yield of one isomer over the other?
- What commercial uses are there for the products made?
- What conclusions can be drawn about the presence of a particular functional group and its potential for reaction? (319-8)

Notes

PH Chemistry
Chapter 22.1, 22.2, 22.4, 23.1, 23.2, 23.3, 12.2, 12.3

<u>*Core Activities*</u>
PEI Lab
“Ester Synthesis”

Check NB Government Portal for current links and shared resources
https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Polymerization

(1 hour)

NB Prescribed Outcomes

Students will be expected to

- **describe processes of polymerization and identify some important natural and synthetic polymers (319-9)**
  - define and outline the structures of monomers, polymers, and polymerization
  - identify addition and condensation polymerization reactions

- **define problems to facilitate investigation of polymers (212-2)**

Elaborations

Students should define and outline the structures of monomers, polymers, and polymerization. Students should identify addition and condensation polymerization reactions. Condensation polymerization involving polyester products should be relatively easy for the students to grasp as esterification reactions are included in the ―Writing and Balancing Chemical Equations" section.

Students should research a polymer, define the substances needed to make it, and list problems associated with its formation, structure, and/or use.

Teaching Suggestions

Students could provide examples of polymerization in living and/or non-living systems. Students could integrate their understanding of functional groups and reactivity and extend this to the production of polymers.

Teachers might introduce various experiments that use monomers, polymers, and polymerization. Connections could be made to the features of reactants that make them potential monomers.

Students might experiment with the production of a polymer such as nylon or rayon in the laboratory.

Polymerization con't

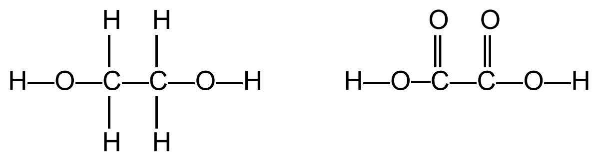
Tasks for Instruction and/or Assessment

Journal

- If you could be any polymer, which polymer would you be? Why? (212-2, 319-9)

Paper and Pencil

- List some examples where polymers have replaced metals. What properties are polymers capable of having that makes them so useful? (319-9)
- A simple polyester can be made from the reaction of



What type of polymerization is this? Write a structural formula for a portion of the polymer chain. (319-9)

- A simple polymer can be made from propene (CH_3-H=CH_2).What type of polymerization is this? Write a structural formula for a portion of the polymer chain. (3 19-9)

Notes

PH Chemistry
Chapter 23.4

<u>*Core Activities*</u>
Small Scale Lab – p.753
"Polymers"

PEI Lab
"Organic Compounds 2: Structure and Nomenclature of Organic Compounds

Check NB Government Portal for current links and shared resources *https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx*

Organic Experimentation

(2 hours)

NB Prescribed Outcomes

Students will be expected to

- **design an experiment identifying and controlling major variables (212-3)**
- **select and use apparatus and material safely (213-8)**

Elaborations

Students should perform a simple demonstration of the proper use of the apparatus for an organic lab. Students could select and use apparatus safely in the distillation of alcohol, the preparation of an ester, or the synthesis of nylon.

Teaching suggestions

Students could do research to design an experiment to prepare an ester, acetylsalicylic acid, soap, or a polymer such as nylon. Students could research the type of alcohol and acid required to synthesize an ester with a desired odour. An ester synthesis experiment would provide students with the opportunity to complete condensation reactions involving alcohols and acids. Due to the often strong odours of organic molecules, all experiments, should be carried out with proper ventilation and students should be required to follow all safety procedures. Some students might be too sensitive to the odours to participate in the experiments and special notification might be required if the school is deemed a scent-free environment.

Organic Experimentation con't

Tasks for Instruction and/or Assessment

Performance

- Select and safely use the apparatus and materials for a boiling point lab. (213-8)
- What apparatus is needed to do a boiling point laboratory? (213-8)
- Design a checklist of safety procedures for the ester lab. This list should check for your knowledge and application of the procedures. (213-3, 213-8)
- Perform and write a report on the experiment that you performed. (319-8)
- Design an experiment to test the purity of aspirin. Identify and control the variables. Conduct the experiment. (212-2, 212-3)

Paper and Pencil

- Write up your aspirin laboratory results as a newspaper article or memo to a company. Include evidence in your report. (213-3, 213-8)

Notes

Core Activities

Student Designed Experiment

Check NB Government Portal for current links and shared resources *https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx*

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

(2 hours)

NB Prescribed Outcomes

Students will be expected to

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

Elaborations

The three outcomes 116-6, 118-2, and 215-5 are discussed as a group and can be addressed in a variety of ways.

Teaching suggestions

This section could be based on an STSE question prepared by groups of students as mentioned in So Many Compounds or on an organic molecule that is synthesized for commercial use. Either strategy covers the outcomes as an activity.

Students could be introduced to different issues relating organic chemistry to their lives. These issues could also be presented by students at the end of the unit. Students could choose one organic molecule that is synthesized for commercial use. This molecule might be a polymer, or it might belong to one of the families that were studied earlier. If it contains functional groups that have not been studied in this unit, the students could research it to identify the groups present.

It is interesting that the ability to synthesize organic molecules artificially was considered impossible until about 170 years ago. It was thought that organic compounds could come only from living sources. In 1828, German chemist Freidrich Wöhler synthesized a common organic compound, urea, from the inorganic compound ammonium cyanate.

Thomas Midgley synthesized the first chlorofluorocarbon (CFC) years later. Many people consider the subsequent attack on Earth's atmosphere to have many ramifications in science and technology. Human history and the study of chemistry were changed by these experiments.

Students could undertake an independent research project and write a research paper about the environmental impact(s) of a particular organic compound. The two-page research paper could include:

- the structure and composition of compound
- the intended use of the compound
- a list and explanation of the benefits and risks to society and the environment according to its manufacturer
- a list and explanation of the benefits and risks to society and the environment according to other sources
- a recommendation on the basis of the risks and benefits whether this product should continue to be marketed
- a list of all reference materials used

These outcomes could be given to the students as guidelines for their paper. The students should locate additional resources on the Internet or at the local library. Time should be taken in class to examine the elements of a research paper. Examples should be used to show students how information is referenced. This is an opportunity to review various formats and conventions of research papers/reports. The purpose of the paper is to have the students experience the process of formulating a thesis and supporting it with evidence.

Tasks for Instruction and/or Assessment

Paper and Pencil

Discuss the information below with reference to
- the risks and benefits to society and the environment
- technological solutions involved
- scientific principles involved. (118-2, 116-6, 215-5)

- Develop and defend your position on the development and use of CFCs. (215-5, 214-9, 118-4)

- Undertake an independent research project on the environmental impact of an organic chemical and write a research paper. (118-4, 214-9, 116-6, 118-2, 215-5)

- When chemical engineers are doing a cost-benefit analysis on a chemical they have just synthesized, what questions might they ask? Include the cost associated with using up our natural resources. (118-4, 214-9, 118-2, 215-5)

Presentation

- Debate the positive and negative effects of an organic compound or a group of organic compounds. (117-4, 215-1)

- Have a research visitor to the classroom to talk about how real chemists conduct research or design synthetic routes to chemicals. (118-4, 116-6)

- Many organic chemicals have shortened names. PVC, PTFE, LDPE, PS, CFC, PET, DDT, DEHP, HDPE, ABS, PAN, BPA, TCDD, DDE, HCFC, PCB, 2,4,5-T, EDTA, ABT-594, ASA … From this list have students choose in pairs one of the chemicals, research its chemical name, formula, structure, properties, historical context, applications, possible health or environmental effects and any interesting facts about the chemical. Students could make a model of the chemical and present their information to the class.

Notes

PH Chemistry
Chapter 22.5, 23.4 *(for Risks and Benefits of Organic Compounds: STSE Perspectives (1) and (2))*

Check NB Government Portal for current links and shared resources https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

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

NB Prescribed Outcomes

Students will be expected to

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

Elaborations
These outcomes could be addressed in a variety of ways.

Teaching suggestions
Students could be asked to prepare a presentation in which they discuss the features of the molecule of choice. Students could research information on their molecules using recent publications and the Internet to ensure the information is as current as possible. The presentation should include visual aids in which the students build a model of their molecule and collect samples of products that contain the molecule. The presentations should discuss the history of the molecule, its means of production, its uses, and any risks associated with its use. This presentation could be designed as a board room promotion in which the students are trying to persuade shareholders to invest in the production of their molecule.

Student presentations could be performed in the context of a grant proposal involving forecasted production costs, budget summaries, stock prices of actual investments, and identification of existing chemical research and development companies. Questions and answers should follow each presentation with other students challenging the presenter if the presentation lacked details or credibility. Class members could act as potential investors and want to know all the relevant information before making a choice.

Risks and Benefits of Organic Compounds: STSE Perspectives (2) con't

Tasks for Instruction and/or Assessment

Journal

- Is all the negative concern about synthesized organic compounds justified? Support your answer. (213-7, 215-3, 117-4, 215-1)

- If life can form various carbon types of compounds, according to the periodic law, what about silicon? Should we be searching for life on other planets that are only carbon based, or silicon based as well? Can we make androids since silicone is also a semi-conductor What is the prevalent mineral on Earth – Silicon. So why is life carbon based and not silicone based? (It is because silicone chain lengths are only approximately 4 long. If this is presented correctly, it could be used nicely to illustrate that the periodic trend is valuable, but not perfect. Shape is crucial.)

Paper and Pencil

- Design an assessment criteria for the presentation. Have the class arrive at consensus. (213-7, 215-3)

Presentation

- As a team, choose an organic chemistry-related issue and discuss how it is related to your life. Describe the impact of technology and express your opinion on the impact of your issue on society.

  Some suggestions are poisons, chemical warfare, starch and proteins, or fat content in milk. Present this as a laboratory activity, a debate, or a talk accompanied with visuals. (213-7, 215-3, 117-4, 215-1)

Notes

Check NB Government Portal for current links and shared resources https://portal.nbed.nb.ca/tr/lr/HSS/Pages/default.aspx

Appendix A Materials List for Core Activities

Chemistry 12

Unit 1 – Thermochemistry			
Topic	**Activity**	**Equipment**	**Chemicals**
Enthalpy Changes	***PEI Labs*** *"Heat Capacity of a Calorimeter"*	Aluminum shot, test tube, 1000C water bath, thermometer, coffee cup calorimeter, electronic balance, water	None
Enthalpy Changes	***PEI Labs*** *"Heat of Reaction"*	Coffee-Cup Calorimeter, 500 mL beaker, thermometer, graduated cylinder, 50 mL beaker	1M NaOH(aq), 1MHCl
Enthalpy Changes	***PEI Labs*** *"Specific Heat of a Metal"*	Safety Goggles, hot plate, Metal, shot, Balance, 2 Styrofoam coffee-cups, 150-mm test tube, 400-mL beaker, 2 thermometers, 50 mL graduated cylinder	None
Thermochemistry Experimentation	**Quick Lab** – p. 522 *"Heat of Fusion of Ice"*	ice foam cup, 100 ml graduated cylinder, thermometer, temperature probe (optional)	None
Thermochemistry Experimentation	**Small Scale Lab** – p. 533 *"Heat of Combustion of a Candle"*	candle, aluminum foil, matches, ruler, balance scale, temp. probe (optional)	None
Bonding and Hess' Law	***PEI Labs*** *"Hess' Law"*	Styrofoam calorimeter, 500 mL beaker, thermometer	0.500M HCl, Mg, MgO

Unit 2 – From Solutions to Kinetics to Equilibrium			
Topic	**Activity**	**Equipment**	**Chemicals**
Kinetics and Rate of Reaction	**Inquiry Activity** – p.540 *"Temperature and Reaction Rates"*	masking tape, 4 plastic cups, thermometer, timer (with seconds), graph paper, pen/pencil	Hot and cold tap water, ice, 4 antacid tablets
Kinetics and Rate of Reaction	***Lab Manual*** *– Lab 36, p.225* *"Factors Affecting Reaction Rates"*	safety goggles, gloves, 10 ml graduated cylinder, 16 medium test tubes, two 250 ml beakers, ring stand, ring support, wire gauze, thermometer, gas burner, test tube rack, watch or timer, aluminum foil, crucible tongs, 100 ml graduated cylinder, 250 ml plastic bottle, tape for label, dropper pipette, metal cutter, centigram balance, paper towels	1.0 M HCl, ice, zinc strips, steel wool, wood splints, matches, distilled water, 3% hydrogen peroxide, 0.1M iron(III)chloride, 0.1M sodium chloride, 0.1M iron(III)nitrate, 0.1M calcium chloride, 0.1M potassium nitrate, 0.1M magnesium chloride, 0.1M hydrochloric acid, 1M hydrochloric acid, 3M hydrochloric acid, 3M hydrochloric acid, powdered zinc
Kinetics and Rate of Reaction	***Lab Manual*** *– Lab 39, p.243* *"A Solubility Product Constant"*	safety goggles, 2-250 ml beakers, centigram balance, 100 ml graduated cylinder, ring stand, ring support, wire gauze, gas burner, glass stirring rod, filter funnel, plastic wash bottle, drying oven/heat lamp, filter paper	saturated lead (II) chloride solution, 0.5M potassium chromate, distilled water
Collision Theory, Reaction Mechanisms and Catalysts	***Small Scale Chemistry Laboratory Manual*** *– lab 28, p.197* *"Factors Affecting the Rate of a Chemical Reaction"*	plastic cups	HCl, Sodium hydrogen carbonate, water, magnesium, calcium carbonate, ice, hot water
Collision Theory, Reaction Mechanisms and Catalysts	***PEI Lab*** *"The Clock Reaction"*		
Chemical Equilibrium (1)	***Small Scale Chemistry Laboratory Manual*** *– lab 29, p.203* *"Le Châtelier's Principle and Chemical Equilibrium "*	empty pipette for stirring, plastic cup	Bromothymol blue, HCl, NaOH, NH_3, Copper(II) sulfate, Lead(II) nitrate, KI, HNO_3, silver nitrate, sodium carbonate, sodium thiosulphate, sodium phosphate

Unit 3 – Acids and Bases			
Topic	**Activity**	**Equipment**	**Chemicals**
Properties and Definitions of Acids and Bases	***PEI Lab*** *"Determination of pH"*	1 x Volumetric Pipette & bulb, 3 x 100mL beaker (for stock solution), 1 x 50 mL beakers, 1 x 100 Volumetric Flask and stopper, plastic pipette, pH meter	Distilled water, NaOH
Properties and Definitions of Acids and Bases	**Inquiry Activity** – p.586 *"Effect of Foods on Baking Soda"*	knife, paper towels, paper plates, baking soda	variety of fruits and vegetables
H+, OH-, and Le Châtelier	**Quick Lab** – p.604 *"Indicators from Natural Sources"*	knife, 1-cup measure, 2 jars, clean white cloth, teaspoon, tape, 3 sheets of plain white paper, pencil, ruler, 10 clear plastic cups, dropper	red cabbage leaves, hot water, white vinegar, baking soda, household ammonia, various household items (salt etc)
H+, OH-, and Le Châtelier	***Lab Practical*** *19-1 "Acids, Bases, and Salts: Determining pH", Laboratory Manual Reference: Expt. 40*	pH paper or pH meters, stirring rod, safety goggles, apron	vinegar, milk, potassium hydroxide, sodium hydrogen carbonate, hydrochloric acid, distilled water
Acid/Base Reactions/ Acid/Base Titrations	***PEI Lab*** *"Acid/Base Titration"*	burette, 100 ml Volumetric flask, 10 ml pipette, 25 ml pipette, 3 Erlenmeyer flasks (50 ml or more)	vinegar, phenolphthalein indicator, 0.300M NaOH

Unit 4 – Organic Chemistry			
Topic	**Activity**	**Equipment**	**Chemicals**
Naming and Writing Organic Compounds	***Lab Manual –*** *Lab 49, p.291 "Hydrocarbons: A Structural Study"*	molecular model kit	none
Naming and Writing Organic Compounds	***PEI Labs*** *"Structure & Nomenclature of Organic Compounds 1"*	molecular model kit	none
Isomers in Organic Chemistry	**Quick Lab** – p. 707 *"Isomers of Heptane"*	molecular model kit	none
Isomers in Organic Chemistry	**Small Scale Lab** – p. 708 *"Hydrocarbon Isomers"*	toothpicks, modeling clay	none
Writing and Balancing Equations	***PEI Labs*** *"Ester Synthesis"*	Test Tube Erlenmeyer Flask (125 mL)	acetic acid 1-pentanol, acetic anhydride, salicylic acid, Glacial Acetic acid
Polymerization	**Small Scale Lab** – p.753 *"Polymers"*	3.5 100 ml plastic cups,straws, plastic spoons, pipette, powdered guar gum	4% borax sol'n,
Polymerization	***PEI Labs*** *"Structure & Nomenclature of Organic Compounds 2"*	molecular model kit	none