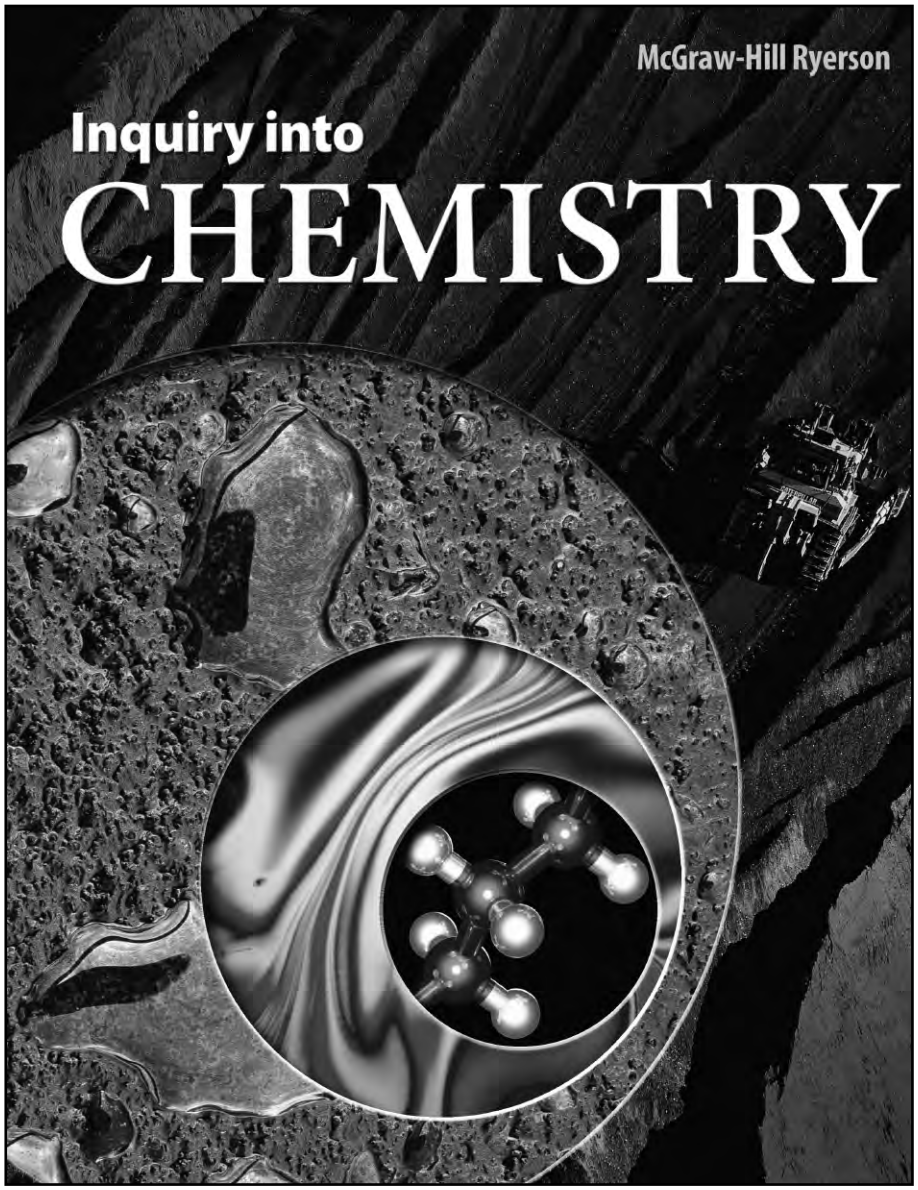
Inquiry into Chemistry

Curriculum Correlation

To the new **Chemistry 20-30** Program of Studies



McGraw-Hill Ryerson

CHAPTER 1 CHEMICAL BONDING

Curriculum Correlation

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

	Student Textbook	Assessment Options
Outcomes for Knowledge		
20–A1.1k recall principles for assigning names to ionic compounds	Unit Preparation, pp. 10-13 Launch Lab: Chemistry Recall, Chapter 1, p. 15 Binary Ionic Compounds, Unit 1 Preparation, p. 10	 Launch Lab Analysis: 1, Chapter 1, p. 5 Section 1.1, Questions for Comprehension: 9, p. 34 Section 1.1 Review, 7–11, p. 35 Section 1.2 Review: 8, 10, p. 42 Chapter 1 Test BLM 1.0.7 Simple Binary Ionic Quiz BLM 1.0.8 Stock System Binary Ionic Compound Nomenclature and Formulas Quiz BLM 1.0.9 Mixed Ionic Compound Nomenclature and Formulas Quiz Unit 1 Review: 15, 16, pp. 86–89
20–A1.2k explain why formulas for ionic compounds refer to the simplest whole-number ratio of ions that result in a net charge of zero	Forming Ionic Bonds, Section 1.1, p. 20. 21 Using the Charge to Determine the Chemical Formula of an Ionic Compound, Section 1.2, p. 21	Section 1.1, Questions for Comprehension: 7, p. 21 Chapter 1 Review: 26, p. 44 Chapter 1 Test Unit 1 Review: 2–4, 13, 14, 40, 42, pp. 86–89
20–A1.3k define valence electron, electronegativity, ionic bond and intramolecular force	Unit 1 Preparation, pp. 8-9 Forming and Representing Compounds, Section 1.1, pp. 18-20, 23-29 Electronegativity, Section 1.2, p. 36 Size and Electronegativity, Section 1.2, p. 37 The Nature of Chemical Bonds, Section 1.2, pp. 39-42, 63	 Section 1.1 Review: 2, 7, p. 35 Section 1.2 Review: 1, 3–5, 7, 8, 10, p. 42 Chapter 1 Review: 8, 19-21, p. 44-45 Chapter 1 Test Unit 1 Review: 1, 2, 4, 5, 7–9, 12, 17, 20, 26–28, 41, 45, 50, 52, 54, pp. 86–89
20–A1.4k use the periodic table and electron dot diagrams to support and explain ionic bonding theory	Forming Bonds, Unit 1 Preparation, p. 8–9 Forming and Representing Compounds, Section 1.1, pp. 19-20, 18-31 Electronegativity, Section 1.2, p. 36 Size and Electronegativity, Section 1.2, p. 37	Questions for Comprehension: 1–5, Section 1.1, p. 19 Section 1.1 Review: 1, 3–5, p. 35 Section 1.2 Review: 7, p. 42 Chapter 1 Review: 23, 26, 28, 34, p. 44-45 Unit 1 Review: 1, 2, 4, 7, 12–14, 26, 41, 51, 52, 57 , pp. 86–89

	Student Textbook	Assessment Options
Skill Outcomes (Focus on scientific inquiry)		
20–A1.5k explain how an ionic bond results from the simultaneous attraction of oppositely charged ions	Forming Bonds, Unit 1 Preparation, p. 9 Forming and Representing Compounds, Section 1.1, pp. 18-31	Section 1.1 Review: 3, 7, 9, p. 35 Section 1.2 Review: 2, 3, 6, 8, 10, p. 42 Chapter 1 Review: 9, 10, 14–17, p. 36 Chapter 1 Test Unit 1 Review: 4, 9, 21, 26, 27, 28, 32, 39, pp. 86–89
20–A1.6k explain that ionic compounds form lattices and that these structures relate to their properties, e.g., *melting point, dissolving, reactivity.*	Sample Problem: Drawing Lewis Structures, p. 15 Connections: Ionic Liquids, Section 1.1, p. 22 Three-Dimensional Structures, Section 2.1, pp. 48-50	 Connections: Ionic Liquids, Section 1.1, p. 22 Chapter 1 Test Unit 1 Review: 3, 5, 6, 8, 10, 11, 30, 37–39, pp. 86–89
Outcomes for Science, Technology and Society (Emphasis on the nature of science)		
20–A1.1sts explain that the goal of science is knowledge about the natural world by ■ *identifying everyday processes and products in which ionic compounds are significant, such as in the composition of household products and foods and in life processes*	Clues in Naturally Occurring Substances, Section 1.1, p. 16 Connections: Ionic Liquids, Section 1.1, p. 22 Bonding in Biological Molecules, Section 2.2, pp. 69-70 Connections: Mane Products, Section 2.3, p. 79	 Connections: Ionic Liquids: 1, 3, Section 1.1, p. 22 Unit 1 Review: 62–65, pp. 86–89
20–A1.2sts explain that scientific knowledge and theories develop through hypotheses, collection of evidence through experimentation and the ability to provide explanations by ■ *describing how an understanding of electronegativity contributes to the knowledge of relative bond strength, melting points and boiling points of ionic substances*	Clues in Naturally Occurring Substances, Section 1.1, p. 16 Connections: Ionic Liquids, Section 1.1, p. 22	 Connections: Ionic Liquids: 1, 3, Section 1.1, p. 22 Chapter 1 Review: 33-35, p. 45 Unit 1 Review: 62–65, pp. 86–89
20–A1.3sts explain that scientific knowledge may lead to the development of new technologies and that new technologies may lead to scientific discovery by ■ *explaining how scientific research and technology interact in the production and distribution of beneficial materials, including semiconductors, ceramics and composite materials.*	Chapter 1 Opener, p. 14 Connections: Ionic Liquids, Section 1.1, p. 22 Career Focus: Ask a Nanotechnologist, p. 84-85	 Career Focus: Ask a Nanotechnologist: 1-4, p. 84-85 Unit 1 Review: 62–65, pp. 86–89

	Student Textbook	Assessment Options
Skill Outcomes (Focus on scientific inquiry)		
Initiating and Planning		
20–A1.1s ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by ■ designing an investigation to determine the properties of ionic compounds (solubility, conductivity, melting point) ■ describing procedures for safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information ■ *researching the question "Should all scientific research have a practical application?"* ■ *designing an experiment to explore the formation of ionic compounds.*	Safety in Your Chemistry Laboratory and Classroom, p. xiv Connections: Ionic Liquids, Section 1.1, p. 22 Investigation 1.A: Modelling Molecules, Section 1.1, p. 30	Questions for Comprehension: 4, Unit 1 Preparation, p. 19 Connections: Ionic Liquids: 3, Section 1.1, p. 22 Investigation 1.A: Modelling Molecules: 3, Section 1.1, p. 30 Section 1.1 Review: 1, p. 35 Chapter 1 Review: 26, p. 44 Unit 1 Review: 45, 62–65, pp. 86–89
Performing and Recording		
20–A1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by ■ drawing electron dot diagrams and building models of ionic solids ■ *performing an investigation to illustrate properties of ionic compounds* ■ *using the periodic table to make predictions about bonding and nomenclature* ■ *using model building software to collect and integrate information on the structure of ionic crystals.*	Forming Ionic Bonds, Section 1.1, pp. 19-21 Electronegativity, Section 1.2, p. 36 Size and Electronegativity, Section 1.2, p. 37 Bond Type and Electronegativity, Section 1.2, p. 39 Investigation 2.A: Building Ionic Crystals, Section 2.1, p. 51	Section 1.2, Questions for Comprehension: 11, 12, p. 41 Investigation 2.A: Building Ionic Crystals, Analysis 1, Section 2.1, p. 51 Unit 1 Review: 45, pp. 86–89
Analyzing and Interpreting		
20–A1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions by ■ *analyzing experimental data to determine the properties of ionic compounds* ■ *using data from various sources to predict the strength of bonds between ions.*	Connections: Ionic Liquids, Section 1.1, p. 22 The Nature of Chemical Bonds, Section 1.2, p. 36-42 Investigation 2.E: Properties of Substances, Section 2.3, p. 78	Connections: Ionic Liquids, Section 1.1, p. 22 Section 1.1 Review: 7-10, p. 35 Unit 1 Review: 8, 64, pp. 86–89
Communication and Teamwork		
20–A1.4s work as members of a team in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results by ■ critically analyzing models of ionic compounds built by others.	Investigation 2.A: Building Ionic Crystals, Section 2.1, p. 51	Investigation 2.A: Building Ionic Crystals, Analysis: 2, Section 2.1, p. 51

CHAPTER 2 DIVERSITY OF MATTER

Curriculum Correlation

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

	Student Textbook	Assessment Options
Outcomes for Knowledge		
20–A2.1k recall principles for assigning names to molecular substances	Covalently Bonded Compounds, Unit 1 Preparation, p. 10-11	Questions for Comprehension: 5, 6, p. 13 Section 1.1 Review: 10-12, p. 35 Chapter 1 Review: 16, 18, p. 44-45 Practice Problems: 1-10, Section 2.1, p. 56 Chapter 2 Test Unit 1 Review: 3, 13, 15, 16, pp. 86–89
20–A2.2k explain why formulas for molecular substances refer to the number of atoms of each constituent element	Covalently Bonded Compounds, Unit 1 Preparation, p. 10-11	Questions for Comprehension: 5, 6, p. 13 Chapter 2 Test Unit 1 Review: 4, 9, 11, 13, 31–34, 40, 45, 46, 50, 58, pp. 86–89
20–A2.3k relate electron pairing to multiple and covalent bonds	Chemical Bonds, Section 1.1, p. 18 Forming Covalent Bonds, Section 1.1, p. 23 Coordinate Covalent Bonds, Section 1.1, p. 28 VSEPR and the Structures of Molecular Compounds, Section 2.1, p. 52	Questions for Comprehension: 2, p. 19 Section 1.1 Review: 2, p. 35 Section 1.2 Review: 2, 7, p. 42 Chapter 2 Test Unit 1 Review: 1, 4, 9, 12, 13, 19, 20, 21, 23, 34, 49, 50, pp. 86–89
20–A2.4k draw electron dot diagrams of atoms and molecules, writing structural formulas for molecular substances and using Lewis structures to predict bonding in simple molecules	Electron Dot Diagrams, Unit 1 Preparation, p. 8 Clues in Naturally Occurring Substances, Section 1.1, p. 16-18 Forming Covalent Bonds, Section 1.1, p. 23 Sample Problem: Drawing Lewis Structures, Section 1.1, p. 24 Drawing Lewis Structures for Simple Molecules and Polyatomic Ions, Section 1.1, p. 25 Sample Problem: Drawing the Lewis Structure of a Molecule, Section 1.1, p. 26 Investigation 1.A: Modelling Molecules, Section 1.1, p. 30	Questions for Comprehension: 1-5, Section 1.1, p. 19 Questions for Comprehension: 6, Section 1.1, p. 21 Practice Problems: 1-6, Section 1.1, p. 25 Practice Problems: 6-16, Section 1.1, p. 27 Section 1.1 Review: 3-6, 15, p. 35 Chapter 1 Review: 3-8, 27, 28, 32, p. 44-45 Chapter 2 Test Unit 1 Review: 12, 14, 55, pp. 86-89
20–A2.5k apply VSEPR theory to predict molecular shapes for linear, angular (bent, V-shaped), tetrahedral, trigonal pyramidal and trigonal planar molecules	VSEPR and the Structure of Molecular Compounds, Section 2.1, p. 52–54 Using VSEPR Theory to Predict Molecular Shapes, Section 2.1, p. 55–59 Sample Problem: Predicting Molecular Shape for a Simple Compound, Section 2.1, p. 56	Practice Problems: 1–10, 11–16, Section 2.1, p. 56, 59 Questions for Comprehension: 3, 4, Section 2.1, p. 57 Section 2.1 Review: 5-17, p. 62 Chapter 2 Review: 1, 10, 19, p. 82-83 Chapter Test 2 Test Unit 1 Review: 6, 9, 18, 19-21, 58, 60, 61, pp. 86–89

	Student Textbook	Assessment Options
20–A2.6k illustrate, by drawing or building models, the structure of simple molecular substances	Investigation 1.A: Modelling Molecules, Section 1.1, p. 30 Investigation 2.B: Soap Bubble Molecules, Section 2.1, p.56 Investigation 2.C: Dipole Balloons, Section 2.2, p. 64	Investigation 1.A: Modelling Molecules, Procedure 5, Section 1.1, p. 30 Investigation 2.B: Soap Bubble Molecules: 1-3, Section 2.1, p. 56 Investigation 2.C: Dipole Balloons: 1–4, Section 2.2, p. 64 Chapter 2 Test Unit 1 Review: 6, 9, 18, 19-21, 58, 60, 61, pp. 86–89
20–A2.7k explain intermolecular forces, London (dispersion) forces, dipole-dipole-forces and hydrogen bonding	Investigation 1.A: Modelling Molecules, Section 1.1, p. 30 Dipole-Dipole Forces, Section 2.2, p. 63 Hydrogen Bonding, Section 2.2, p. 64 London (Dispersion) Forces, Section 2.2, p. 67	Investigation 1.A: Modelling Molecules, Analysis 2, Section 1.1, p. 30 Questions for Comprehension: 5–7, Section 2.2, p. 69 Section 2.2 Review: 1–8, p. 70 Chapter 2 Review: 2–8, 11, p. 82 Chapter 2 Test Unit 1 Review: 9, 17, 19, 24, 26, 28, 31–35, 38, 40, 49, 50, 54, pp. 86–89
20–A2.8k relate properties of substances (e.g., *melting and boiling points, enthalpies of fusion and vaporization*) to the predicted intermolecular bonding in the substance	Investigation 2.D: Investigating the Properties of Water, Section 2.2, p. 66 Relating Structures and Properties, Section 2.3, p. 71 Mechanical Properties of Solids, Section 2.3, p. 75 Investigation 2.E: Properties of Substances, Section 2.3, p. 78 Melting Points and Boiling Points, Section 2.3, p. 72 Conductivity, Section 2.3, p. 76	Investigation 2.D: Investigating the Properties of Water: 1–7, Section 2.2, p. 66 Questions for Comprehension: 5–7, Section 2.2, p. 69 Section 2.2 Review: 3, 6-8, p. 70 Questions for Comprehension: 8–10, Section 2.3, p. 75 Section 2.3 Review: 1–10, p. 80 Chapter 2 Review: 2–10, 13, 14, 17–19, 24, 41, p. 82–83 Chapter 2 Test Unit 1 Review: 5, 8-11, 19, 20, 25, 29, 31, 35, 36, 42, 47, 48, 51, 53, 62–65, pp. 86–89
20–A2.9k determine the polarity of a molecule based on simple structural shapes and unequal charge distribution	VSEPR and the Structure of Molecular Compounds, Section 2.1, p. 52 Using VSEPR Theory to Predict Molecular Shapes, Section 2.1, p. 55 Polar Bonds and Polar Molecules, Section 2.1, p. 57	Chapter 1 Review: 22, 23, 24, 35, p. 44-45 Section 2.1 Practice Problems: 1-10, 11-16, p. 56, 59 Questions for Comprehension: 3, Section 2.1, p. 57 Section 2.1 Review: 10-17, p. 62 Chapter 2 Review: 1, 5, 6, 12, 16, 19, 23, p. 82-83 Chapter 2 Test Unit 1 Review: 5, 7, 8 19, 20, 40, 41, 43, 44, 46, 49, 59–61, pp. 86–89
20–A2.10k describe bonding as a continuum ranging from complete electron transfer to equal sharing of electrons.	Bond Type and Electronegativity, Section 1.2, p. 39	Section 1.2 Review: 6, p. 42 Chapter 1 Review: 25, p. 44-45 Chapter 1 Test Unit 1 Review: 4, 9, 20, 40, pp. 86–89

	Student Textbook	Assessment Options
Outcomes for Science, Technology and Society (Emphasis on the nature of science)		
20–A2.1sts explain that scientific knowledge and theories develop through hypotheses, the collection of evidence through experimentation and the ability to provide explanations by ■ *relating chemical properties to their predicted intermolecular bonding by investigating melting and boiling points*	Melting Points and Boiling Points, Section 2.2, p. 72 Mechanical Properties of Solids, Section 2.3, p. 75 Investigation 2.E: Properties of Substances, Section 2.3, p. 78	Chapter 2 Review: 14, 15-18, 28-30, p. 82-83 Unit 1 Review: 45, 62–65, pp. 86–89
20–A2.2sts explain that scientific knowledge is subject to change as new evidence comes to light and as laws and theories are tested and subsequently restructured, revised or reinforced by ■ *explaining how scientific research and technology interact in the production and distribution of beneficial materials, e.g., polymers, household products, life processes, solvents* ■ i*nvestigating how basic knowledge about the structure of matter is challenged in nanotechnology research and development.*	Chemistry File: FYI (sidebar), Section 2.1, p. 60 Network Solids, Section 2.1, p. 60 Career Focus: Ask a Nanotechnologist, p. 84-85	Chapter 2 Review: 14, 15-18, 28-30, p. 82-83 Unit 1 Review: 62–65, pp. 86–89
Skill Outcomes (Focus on scientific inquiry)		
Initiating and Planning		
20–A2.1s ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by ■ stating a hypothesis and making a prediction about the properties of molecular substances based on attractive forces; *e.g., melting or boiling point, enthalpy of fusion, enthalpy of vaporization* ■ describing procedures for safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labeling information.	Relating Structures and Properties, Section 2.3, pp. 71-74 Investigation 2.D: Investigating the Properties of Water, Section 2.2, p. 66 Investigation 2.E: Properties of Substances, Section 2.3, p. 78	Investigation 2.D: Investigating the Properties of Water, Analysis: 1–6, Conclusion: 7, Section 2.2, p. 66 Investigation 2.E: Properties of Substances, Analysis: 1, Conclusion: 2, Section 2.3, p. 78 Unit 1 Review: 45, 62–65, pp. 86–89
Performing and Recording		
20–A2.2s conduct investigations into relationships among observable variables, and use a broad range of tools and techniques to gather and record data and information by ■ building models depicting the structure of simple covalent molecules, including selected organic compounds ■ carrying out an investigation to determine the melting or boiling point of a molecular substance ■ *using a thermometer and a conductivity apparatus to collect data* ■ *carrying out an investigation to compare the properties of molecular compounds.*	Investigation 2.B: Soap Bubble Molecules, Section 2.1, p.56 Investigation 2.E: Properties of Substances, Section 2.3, p. 78	Investigation 2.B: Soap Bubble Molecules, Analysis: 1, 2, Conclusion: 3, Section 2.1, p.56 Investigation 2.E: Properties of Substances, Analysis: 1, Conclusion: 2, Section 2.3, p. 78 Unit 1 Review: 45, pp. 86–89

	Student Textbook	Assessment Options
Analyzing and Interpreting		
20–A2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions by ■ graphing and analyzing data, for trends and patterns, on the melting and boiling points of a related series of molecular substances.	Investigation 2.E: Properties of Substances, Section 2.3, p. 78	Investigation 2.E: Properties of Substances, Analysis: 1, Conclusion: 2, Section 2.3, p. 78 Chapter 2 Review: 21, 27, p. 82-83 Unit 1 Review: 8, 52, 64, pp. 86–89
Communication and Teamwork		
20–A2.4s work as members of a team in addressing problems, and apply the skills and conventions of science in communicating information and ideas and in assessing results by ■ objectively evaluating and analyzing models and graphs constructed by others	Investigation 2.A: Building Ionic Crystals, Section 2.1, p. 51 Investigation 2.B: Soap Bubble Molecules, Section 2.1, p.56	Investigation 2.A: Building Ionic Crystals, Analysis: 2, Section 2.1, p. 51 Investigation 2.B: Soap Bubble Molecules, Analysis: 1, 2, Conclusion: 3, Section 2.1, p.56
■ *researching the ways scientists develop and analyze new materials.*	Investigation 2.E: Properties of Substances, Analysis: 1, Conclusion: 2, Section 2.3, p. 78	Investigation 2.E: Properties of Substances, Analysis: 1, Conclusion: 2, Section 2.3, p. 78

CHAPTER 3 PROPERTIES OF GASES

Curriculum Correlation

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

	Student Textbook	Assessment Options
Outcomes for Knowledge		
20–B1.1k describe and compare the behaviour of real and ideal gases in terms of kinetic molecular theory	Properties of Gases, Section 3.1, p. 91, 99 Kinetic Molecular Theory, Section 3.1, p. 100 Gas Pressure and Volume, Section 3.2, p. 104 Investigation 3.A: The Relationship between the Pressure on and the Volume of a Gas, Section 3.2, p. 106 Connections: Technology and the Development of Barometers, Section 3.2, p. 108 Kinetic Molecular Theory and Boyle's Law, Section 3.2, p. 111 Kinetic Molecular Theory and Charles's Law, Section 3.3, p. 121 Connections: Chinook Winds and Gas Laws, Section 4.2, p. 146	ChemistryFile: FYI (sidebar), Section 3.2, p. 105 Section 3.1 Review: 4–9, p. 101 Connections: Technology and the Development of Barometers, 1, Section 3.2, p. 108 Section 3.3 Review: 1–3, p. 122 Chapter 3 Review: 1–7, p. 124 Chapter 3 Test BLM 3.0.5 What do you know about gases? BLM 3.1.2 Properties of Gases BLM 3.1.3 Modelling Gases in the Roller Rink BLM 3.2.4 Charles's Law and the Motion of Molecules Unit 2 Review: 1–3, p. 156–157
20–B1.2k convert between the Celsius and Kelvin temperature scales	Interpreting the Volume versus Temperature Relationship, Section 3.3, p. 115-117, 119-120, 122 Thought Lab 3.1: The Importance of the Kelvin Temperature Scale, Section 3.3, p. 117 Sample Problem: Using Charles's Law to Calculate Volume, Section 3.3, p. 119 Sample Problem: Using Charles's Law to Calculate Temperature, Section 3.3, p. 120 The Combined Gas Law, Section 4.1, p. 130 Ideal Gas Law, Section 4.2, pp 141, 142	Practice Problems: 7, 8, Section 3.3, p. 119 Thought Lab 3.1: The Importance of the Kelvin Temperature Scale, Procedure 3, Section 3.3, p. 117 Questions for Comprehension: 8, 9, Section 3.3, p. 116 Chapter 3 Test BLM 3.3.2 The Celsius and Kelvin Scales Unit 2 Review: 1, 13, p. 156–157

	Student Textbook	Assessment Options
20–B1.3k explain the law of combining gases	Combining Volumes of Gases, Section 4.1, p. 132 Combined Gas Law Calculations, Section 4.1, p. 129 Ideal Gas Law, Section 4.2, p. 139-140 The Combined Gas Law, Section 4.1, p. 128 Connections: Technology and the Process of Discovery, Section 4.1, p. 131	BLM 3.3.5 Gas Pressure, Temperature and Volume Quiz Chapter 3 Test Practice Problems: 1-6, Section 4.1, p. 130 Practice Problems: 7-9, Section 4.1, p. 132 Questions for Comprehension: 1, 2, Section 4.1, p. 132 Questions for Comprehension: 3, 4, Section 4.1, p. 135-136 Chapter 4 Review: 5, 26, 30, 33, p. 152 BLM 4.1.1 Combined Gas Law Problems (1) BLM 4.1.2 Combined Gas Law Problems (2) Unit 2 Review: 10, 19, 24, 29, p. 156–157
20–B1.4k illustrate how Boyle's and Charles' laws, individually and combined, are related to the ideal gas law ($PV = nRT$) ■ express pressure using units of kilopascals, atmospheres and millimetres of mercury ■ perform calculations based on the gas laws under STP, SATP and other defined conditions.	Gases and Molecular Kinetic Theory, Section 3.1, p. 110 Gases and Pressure, Section 3.2, p. 102–104 Boyle's Law, Section 3.2, p. 109 Using Boyle's Law to Calculate Volume, Section 3.2, p. 110 Charles's Law, Section 3.3, p. 117 The Combined Gas Law, Section 4.1, p. 133 Ideal Gas Law, Section 4.2, pp. 142-145	Section 3.2 Review: 1-3, p. 112 Questions for Comprehension: 3, Section 3.2, p. 104 Practice Problems: 14, Section 3.3, p. 120 Chapter 3 Test BLM 3.3.5 Gas Pressure, Temperature and Volume Quiz Unit 2 Review: 5–9, 11, 12, 14–26, p. 156–157
Outcomes for Science, Technology and Society (Emphasis on the nature of science)		
20–B1.1sts explain that science provides a conceptual and theoretical basis for predicting, interpreting and explaining natural and technological phenomena by ■ *describing how the development of technologies capable of precise measurements of temperature and pressure led to a better understanding of gases and the formulation of the gas laws, e.g., thermocouples, thermistors, Bourdon gauges*	Using the Properties of Gases – Gas Technologies, Section 3.1, p. 98-99 Atmospheric Pressure, Section 3.2, p. 102 Gases and Pressure, Gas Pressure and Volume, Gases and Temperature, Section 3.2, p. 102–105 Discovery of Atmospheric Pressure, Section 3.2, p. 102-103 Connections: Technology and the Development of Barometers, Section 3.2, p. 108 The Combined Gas Law, Section 4.1, p. 131	Questions for Comprehension: 2, Section 3.2, p. 104 Connections: Technology and the Development of Barometers: 1, 2, Section 3.2, p. 108 Chapter 3 Review: 1-7, 21-25, p. 124-125 BLM 3.1.4 Research SCUBA

	Student Textbook	Assessment Options
20–B1.2sts explain that the goal of science is knowledge about the natural world by ■ *describing examples of natural phenomena and processes and products that illustrate the properties of gases, e.g., breathing, diffusion, weather, hot air balloons, scuba diving equipment, automobile air bags, gas turbines, internal combustion engines.*	Chapter 3 Launch Lab: Balloon in a Bottle, p. 97 Using the Properties of Gases – Gas Technologies, Section 3.1, p. 98-99 Atmospheric Pressure, Section 3.2, p. 102 Gases and Pressure, Gas Pressure and Volume, Gases and Temperature, Section 3.2, p. 102–105 Investigation 3.A: The Relationship between the Pressure on and the Volume of a Gas, Section 3.2, p. 106–107 Investigation 3.B: The Relationship between Temperature and Volume of a Gas, Section 3.3, p. 114–115 Discovery of Atmospheric Pressure, Section 3.2, p. 102-103	Chapter 3 Launch Lab: Balloon in a Bottle, Analysis: 3, p. 97 Investigation 3.A: The Relationship between the Pressure on and the Volume of a Gas, Analysis: 1–5, Conclusion: 6, Section 3.2, p. 106–107 Investigation 3.B: The Relationship between Temperature and Volume of a Gas, Conclusion: 7, Section 3.3, p. 114–115 Questions for Comprehension: 2, Section 3.2, p. 104 Chapter 3 Review: 1-7, 21-25, p. 124-125 BLM 3.1.4 Research SCUBA
Initiating and Planning		
20–B1.1s ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by ■ stating hypotheses and making predictions based on information about the pressure, temperature and volume of a gas ■ describing procedures for safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information ■ *designing an experiment to illustrate Boyle's and/or Charles' gas laws* ■ *designing an investigation to determine the universal gas constant* (R) *or absolute zero.*	Investigation 3.A: The Relationship between the Pressure on and the Volume of a Gas, Section 3.2, p. 106–107 Investigation 3.B: The Relationship between Temperature and Volume of a Gas, Section 3.3, pp. 114–115 Chapter 4 Launch Lab, Changing Gas Temperature, Pressure, and Volume at the Same Time, p. 127 Safety in the Chemistry Laboratory, pp. xii-xv	Investigation 3.A: The Relationship between the Pressure on and the Volume of a Gas, Analysis: 1, 3-5, Section 3.2, p. 106–107 Investigation 3.B: The Relationship between Temperature and Volume of a Gas, Analysis: 1, 4-7, Section 3.3, pp. 114–115
Performing and Recording		
20–B1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by ■ performing an experiment, in which variables are identified and controlled, to illustrate the gas laws ■ *using thermometers, balances and other measuring devices effectively to collect data on gases* ■ *using library and electronic research tools to collect information on real and ideal gases and applications of gases, e.g., hot air and weather balloons* ■ *performing an investigation to determine molar mass from gaseous volume.*	Investigation 3.A: The Relationship between the Pressure on and the Volume of a Gas, Section 3.2, p. 106–107 Investigation 3.B: The Relationship between Temperature and Volume of a Gas, Section 3.3, p. 114–115 The Combined Gas Law, Section 4.1, p. 137 Ideal Gas Law, Section 4.2, pp. 144-145, 148	Investigation 3.A: The Relationship between the Pressure on and the Volume of a Gas, Analysis: 1, 3–5, Conclusion: 6, Section 3.2, p. 106–107 Investigation 3.B: The Relationship between Temperature and Volume of a Gas, Analysis: 1, 2, 4, 5, Conclusion: 7, Section 3.3, p. 114–115

	Student Textbook	Assessment Options
Analyzing and Interpreting		
20–B1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions by ■ drawing and interpreting graphs of experimental data that relate pressure and temperature to gas volume ■ *identifying the limitations of measurement* ■ *identifying a gas based on an analysis of experimental data.*	Investigation 3.A: The Relationship between the Pressure on and the Volume of a Gas, Section 3.2, p. 106–107 Investigation 3.B: The Relationship between Temperature and Volume of a Gas, Section 3.3, p. 114–115 Thought Lab 3.1: The Importance of the Kelvin Temperature Scale, Section 3.3, p. 117 Interpreting the Volume versus Temperature Relationship, Section 3.3, p. 115 The Combined Gas Law, Section 4.1, p. 137 Ideal Gas Law, Section 4.2, p. 148	Investigation 3.A: The Relationship between the Pressure on and the Volume of a Gas, Procedure 16, 17, Section 3.2, p. 106–107 Investigation 3.B: The Relationship between Temperature and Volume of a Gas, Analysis: 2–5, Conclusion: 7, Section 3.3, p. 114–115 Thought Lab 3.1: The Importance of the Kelvin Temperature Scale, Analysis: 1–6, Section 3.3, p. 117 Chapter 3 Review: 10, 21, p. 124- 125 BLM 3.2.4 Interpreting Graphical Relationships Unit 2 Review: 12, 25, p. 156–157
Communication and Teamwork		
20–B1.4s work as members of a team in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results by ■ communicating questions, ideas and intentions and receiving, interpreting, understanding, supporting and responding to the ideas of others during group work to collect data on gases ■ using appropriate International System of Units (SI) notation, fundamental and derived units and significant digits when performing calculations related to the gas laws ■ *preparing a group presentation, using multimedia, to illustrate how pressure, temperature, volume and amount of a gas determine* R*, the universal gas constant.*	Chapter 3 Launch Lab: Balloon in a Bottle, p. 97 Boyle's Law, Section 3.2, p. 109 Charles's Law, Section 3.3, p. 117 Sample Problem: Using Boyle's Law to Calculate Volume, Section 3.2, p. 110 Sample Problem: Using Charles's Law to Calculate Volume, Section 3.3, p. 119 Sample Problem: Using Charles's Law to Calculate Temperature, Section 3.3, p. 120 Chapter 4 Launch Lab: Changing Gas Temperature, Pressure and Volume at the Same Time, p. 127	BLM 4.2.4 Collecting a Gas in the Laboratory

CHAPTER 4 EXPLORING GAS LAWS

Curriculum Correlation

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

	Student Textbook	Assessment Options
Outcomes for Knowledge		
20–B1.1k describe and compare the behaviour of real and ideal gases in terms of kinetic molecular theory	Investigation 4.A: Finding the Molar Mass of a Gas, Section 4.2, p. 144–145	Investigation 4.A: Finding the Molar Mass of a Gas, Analysis: 3 Conclusion: 6, 7, Section 4.2, p. 144–145 Chapter 4 Review: 6, 7, 10, p. 152 Chapter 4 Test Unit 2 Review: 1–3, p. 156–157
20–B1.2k convert between the Celsius and Kelvin temperature scales	Thought Lab 3.1: The Importance of the Kelvin Temperature Scale, Section 3.3, p. 117 Sample Problem: Using Charles's Law to Calculate Volume, Section 3.3, p. 119 Sample Problem: Using Charles's Law to Calculate Temperature, Section 3.3, p. 120 Interpreting the Volume versus Temperature Relationship, Section 3.3, p. 115-117	Thought Lab 3.1: The Importance of the Kelvin Temperature Scale, Section 3.3, p. 117 Practice Problems: 7, 8, Section 3.3, p. 119 Questions for Comprehension: 8, 9, Section 3.3, p. 116 Chapter 4 Test BLM 3.3.2 The Celsius and Kelvin Scales Unit 2 Review: 1, 13, p. 156–157
20–B1.3k explain the law of combining gases	Combining Volumes of Gases, Section 4.1, p. 132 Combined Gas Law Calculations, Section 4.1, p. 129 Ideal Gas Law, Section 4.2, p. 139-140 The Combined Gas Law, Section 4.1, p. 128 Connections: Technology and the Process of Discovery, Section 4.1, p. 131	Practice Problems: 1-6, Section 4.1, p. 130 Practice Problems: 7-9, Section 4.1, p. 132 Questions for Comprehension: 1, 2, Section 4.1, p. 132 Questions for Comprehension: 3, 4, Section 4.1, p. 135-136 Chapter 4 Review: 5, 26, 30, 33, p. 152 Chapter 4 Test BLM 4.1.1 Combined Gas Law Problems (1) BLM 4.1.2 Combined Gas Law Problems (2) Unit 2 Review: 10, 19, 24, 29, p. 156–157
20–B1.4k illustrate how Boyle's and Charles' laws, individually and combined, are related to the ideal gas law ($PV = nRT$) ■ express pressure using units of kilopascals, atmospheres and millimetres of mercury ■ perform calculations based on the gas laws under STP, SATP and other defined conditions.	The Combined Gas Law, Section 4.1, p. 128 Ideal Gas Law, Section 4.2, p. 139	Practice Problems: 10-16, Section 4.2, p. 141 Practice Problems: 17, Section 4.2, p. 142 Questions for Comprehension: 6, 7, Section 4.2, p. 141 Section 4.2 Review: 1, p. 150 Chapter 4 Review: 12, 16, 18-34, p. 152 Chapter 4 Test Unit 2 Review: 5–9, 11, 12, 14–26, p. 156–157

	Student Textbook	Assessment Options
Outcomes for Science, Technology and Society (Emphasis on the nature of science)		
20–B1.1sts explain that science provides a conceptual and theoretical basis for predicting, interpreting and explaining natural and technological phenomena by ■ *describing how the development of technologies capable of precise measurements of temperature and pressure led to a better understanding of gases and the formulation of the gas laws, e.g., thermocouples, thermistors, Bourdon gauges*	Using the Properties of Gases – Gas Technologies, Section 3.1, p. 98-99 Atmospheric Pressure, Section 3.2, p. 102 Gases and Pressure, Gas Pressure and Volume, Gases and Temperature, Section 3.2, p. 102–105 Discovery of Atmospheric Pressure, Section 3.2, p. 102-103	Connections: Technology and the Development of Barometers: 1, 2, Section 3.2, p. 108 Questions for Comprehension: 2, Section 3.2, p. 104 Chapter 3 Review: 1-7, 21-25, p. 124-125 BLM 3.1.4 Research SCUBA Chapter 4 Review: 35-37, p. 152-153
20–B1.2sts explain that the goal of science is knowledge about the natural world by ■ *describing examples of natural phenomena and processes and products that illustrate the properties of gases, e.g., breathing, diffusion, weather, hot air balloons, scuba diving equipment, automobile air bags, gas turbines, internal combustion engines.*	Chapter 3 Launch Lab: Balloon in a Bottle, p. 97 Using the Properties of Gases – Gas Technologies, Section 3.1, p. 98-99 Atmospheric Pressure, Section 3.2, p. 102 Gases and Pressure, Gas Pressure and Volume, Gases and Temperature, Section 3.2, p. 102–105 Investigation 3.A: The Relationship between the Pressure on and the Volume of a Gas, Section 3.2, p. 106–107 Investigation 3.B: The Relationship between Temperature and Volume of a Gas, Section 3.3, p. 114–115 Discovery of Atmospheric Pressure, Section 3.2, p. 102-103	Chapter 3 Launch Lab: Balloon in a Bottle, Analysis: 3, p. 97 Investigation 3.A: The Relationship between the Pressure on and the Volume of a Gas, Analysis: 1–5, Conclusion: 6, Section 3.2, p. 106–107 Investigation 3.B: The Relationship between Temperature and Volume of a Gas, Conclusion: 7, Section 3.3, p. 114–115 Questions for Comprehension: 2, Section 3.2, p. 104 Chapter 3 Review: 1-7, 21-25, p. 124-125 BLM 3.1.4 Research SCUBA Chapter 4 Review: 35-37, p. 152-153
Initiating and Planning		
20–B1.1s ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by ■ stating hypotheses and making predictions based on information about the pressure, temperature and volume of a gas ■ describing procedures for safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information ■ *designing an experiment to illustrate Boyle's and/or Charles' gas laws* ■ *designing an investigation to determine the universal gas constant* (R) *or absolute zero.*	Chapter 4 Launch Lab: Changing Gas Temperature, Pressure, and Volume at the Same Time, p. 127	Chapter 4 Launch Lab: Changing Gas Temperature, Pressure, and Volume at the Same Time, Analysis: 1–3, p. 127

	Student Textbook	Assessment Options
Performing and Recording		
20–B1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by ■ performing an experiment, in which variables are identified and controlled, to illustrate the gas laws ■ *using thermometers, balances and other measuring devices effectively to collect data on gases* ■ *using library and electronic research tools to collect information on real and ideal gases and applications of gases, e.g., hot air and weather balloons* ■ *performing an investigation to determine molar mass from gaseous volume.*	Chapter 4 Launch Lab: Changing Gas Temperature, Pressure, and Volume at the Same Time, p. 127 Investigation 4.A: Finding the Molar Mass of a Gas, Section 4.2, p. 144–145	Chapter 4 Launch Lab: Changing Gas Temperature, Pressure, and Volume at the Same Time, Analysis: 1–3, p. 127 Investigation 4.A: Finding the Molar Mass of a Gas, Analysis: 1–4, Conclusion: 5–7, Section 4.2, p. 144–145
Analyzing and Interpreting		
20–B1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions by ■ drawing and interpreting graphs of experimental data that relate pressure and temperature to gas volume ■ *identifying the limitations of measurement* ■ *identifying a gas based on an analysis of experimental data.*	Thought Lab 4.1: Molar Volumes of Gases, p. 137	Thought Lab 4.1: Molar Volumes of Gases, Analysis: 1–4, p. 137 Chapter 4 Review: 34, p. 153 BLM 4.1.6 Molar Volumes and the Law of Combining Volumes Problems BLM 4.2.1 Ideal Gas Law Problems Unit 2 Review: 12, 25, p. 156–157
Communication and Teamwork		
20–B1.4s work as members of a team in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results by ■ communicating questions, ideas and intentions and receiving, interpreting, understanding, supporting and responding to the ideas of others during group work to collect data on gases ■ using appropriate International System of Units (SI) notation, fundamental and derived units and significant digits when performing calculations related to the gas laws ■ *preparing a group presentation, using multimedia, to illustrate how pressure, temperature, volume and amount of a gas determine* R*, the universal gas constant.*	Thought Lab 4.1: Molar Volumes of Gases, p. 137 Investigation 4.A: Finding the Molar Mass of a Gas, Analysis: 3 Conclusion: 6, 7, Section 4.2, p. 144–145	Thought Lab 4.1: Molar Volumes of Gases, Analysis: 1–4, p. 137 Investigation 4.A: Finding the Molar Mass of a Gas, Analysis: 3 Conclusion: 6, 7, Section 4.2, p. 144–145 BLM 4.2.4 Collecting a Gas in the Laboratory

CHAPTER 5 SOLUTIONS

Curriculum Correlation

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

	Student Textbook	Assessment Options
Outcomes for Knowledge		
20–C1.1k recall the categories of pure substances and mixtures and explain the nature of homogeneous mixtures	Chapter 5 Launch Lab: Sink or Float? p. 165 Classifying Solutions, Section 5.1, p. 166-168 Investigation 5.D: Preparing and Diluting a Standard Solution, Section 5.4, p. 200	Chapter 5 Launch Lab: Sink or Float? Analysis: 1, 2, p. 165 Investigation 5.D: Preparing and Diluting a Standard Solution, Extension: 3, Section 5.4, p. 200 Questions for Comprehension: 1, 2, Section 5.1, p. 168 Section 5.1 Review: 2, 3, 7, p. 175 Chapter 5 Review: 1-4, p. 204-205 Chapter 5 Test Unit 3 Review: 1, p. 248-251
20–C1.2k provide examples from living and nonliving systems, that illustrate how dissolving substances in water is often a prerequisite for chemical change	Chapter 5 Launch Lab: Sink or Float? p. 165 Solutions in Water, Section 5.1, p. 168-170, 173	Chapter 5 Launch Lab: Sink or Float? Analysis: 1, 2, p. 165 Questions for Comprehension: 3-5, Section 5.1, p. 170 Section 5.1 Review: 3-6, p. 175 Chapter 5 Review: 4, 5, p. 204-205 Chapter 5 Test Unit 3 Review: 2, 30, 35, 38, 43, p. 248-251
20–C1.3k explain dissolving as an endothermic or an exothermic process	Processes of Dissolving, Section 5.1, p. 168-170	Questions for Comprehension: 3-5, Section 5.1, p. 170 Chapter 5 Review: 5, 9, 12, p. 204-205 Chapter 5 Test Unit 3 Review: 2, p. 248-251
20–C1.4k differentiate between electrolytes and nonelectrolytes	Molecular Compounds in Solution, Section 5.1, p. 172-173 Investigation 5.A; Classifying Solutions, Section 5.1, p. 174	Investigation 5.A; Classifying Solutions, Analysis: 1-3, Section 5.1, p. 174 Questions for Comprehension: 7, Section 5.1, p. 175 Chapter 5 Review: 4, p. 204-205 Chapter 5 Test Unit 3 Review: 13, 46, p. 248-251

	Student Textbook	Assessment Options
20–C1.5k express concentration in various ways, i.e., moles per litre of solution, percent by mass, parts per million	The Concentration of Solutions, Section 5.3, p. 184-195 Sample Problem: Solving for Percent by Mass, Section 5.3, p. 186 Sample Problem: Calculating Parts per Million, Section 5.3, p. 188 Sample Problem: Calculating the Concentration of a Solution in mol/L, Section 5.3, p. 190 Sample Problem: Calculating Ion Concentration in mol/L, Section 5.3, p. 192	Questions for Comprehension: 9, Section 5.2, p. 177 Practice Problems: 1-5, Section 5.3, p. 186 Practice Problems: 6-10, Section 5.3, p. 188 Practice Problems: 11-16, Section 5.3, p. 191 Practice Problems: 17-22, Section 5.3, p. 193 Practice Problems: 23-26, Section 5.3, p. 194 Practice Problems: 27-30, Section 5.3, p. 195 Throughout Chapter 5 Chapter 5 Test Unit 3 Review: 3, 4, 6-10, 12, 15, 23, 24, 25, 30, 42, p. 248-251
20–C1.6k calculate, from empirical data, the concentration of solutions in moles per litre of solution and determine mass or volume from such concentrations	Sample Problem: Calculating the Concentration of a Solution in mol/L, Section 5.3, p. 190 Sample Problem: Calculating Mass from Concentration in mol/L, Section 5.3, p. 193	Practice Problems: 11-16, Section 5.3, p. 191 Practice Problems: 23-26, Section 5.3, p. 194 Section 5.3 Review: 1-15, p. 196 Chapter 5 Review: 16-25, p. 204-205 Chapter 5 Test Unit 3 Review: 3, 4, 6-10, 12, 15, 23, 24, 25, 30, 39, 40, 4s2, p. 248-251
20–C1.7k calculate the concentrations and/or volumes of diluted solutions and the quantities of a solution and water to use when diluting	Preparing and Diluting Solutions, Section 5.4, p. 197-201 Sample Problem: Diluting a Standard Solution, Section 5.4, p. 197 Investigation 5.D: Preparing and Diluting a Standard Solution, Section 5.4, p. 200	Practice Problems: 31-33, Section 5.4, p. 198 Investigation 5.D: Preparing and Diluting a Standard Solution, Extension: 4, Section 5.4, p. 200 Section 5.3 Review: 1, 3-15, p. 196 Chapter 5 Review: 24, 25, 30, p. 204-205 Chapter 5 Test Unit 3 Review: 10, 15, 23, 36, p. 248-251
20–C1.8k use empirical data and ionization/dissociation equations to calculate the concentration of ions in a solution	Molar Concentrations of Ions in Solution, Section 5.3, p. 191 Sample Problem: Calculation Ion Concentration in mol/L, Section 5.3, p. 192	Questions for Comprehension: 7, 8, Section 5.1, p. 175 Practice Problems: 17-22, Section 5.3, p. 193 Section 5.3 Review: 9, p. 196 Chapter 5 Test Unit 3 Review: 28, 30, 31, 43, p. 248-251

	Student Textbook	Assessment Options
20–C1.9k define solubility and the factors that affect it	Solubility, Section 5.2, p. 176-177, 181-182	Section 5.1 Review: 1, p. 175 Questions for Comprehension: 6, Section 5.1, p. 172 Questions for Comprehension: 9, Section 5.2, p. 177 Section 5.2 Review: 1, 2, 4, 5, 7, p. 183 Section 5.3 Review: 1, p. 196 Chapter 5 Review: 26-30, p. 204-205 Chapter 5 Test Unit 3 Review: 5, 28, 41, p. 248-251
20–C1.10k explain a saturated solution in terms of equilibrium, i.e., equal rates of dissolving and crystallization	Solubility, Section 5.2, p. 176-179 A Closer Look at a Saturated Solution, Section 5.2, p. 177-179	Questions for Comprehension: 9, Section 5.2, p. 177 Questions for Comprehension: 10, 11, Section 5.2, p. 179 Section 5.2 Review: 1, 3, 6, 7, p. 183 Chapter 5 Review: 7, 8, 12, 30, p. 204-205 Chapter 5 Test Unit 3 Review: 4, 22, 29, p. 248-251
20–C1.11k describe the procedures and calculations required for preparing and diluting solutions.	Preparing and Diluting Solutions, Section 5.4, p. 197-198 Sample Problem: Diluting a Standard Solution, Section 5.4, p. 197	Practice Problems: 31-33, Section 5.4, p. 198 Section 5.3 Review: 1-15, p. 196 Section 5.4 Review: 1-11, p. 202 Chapter 5 Review: 24, p. 204-205 Chapter 5 Test Unit 3 Review: 10, 15, 23, 36, p. 248-251
Outcomes for Science, Technology and Society (Emphasis on social and environmental contexts)		
20–C1.1sts explain how science and technology are developed to meet societal needs and expand human capabilities by ■ *providing examples of how solutions and solution concentrations are applied in products and processes, in scientific studies and in daily life*	Chapter 5 Launch Lab: Sink or Float? p. 165 Connections: Biomagnification and Bioaccumulation, Section 5.3, p. 189	Chapter 5 Launch Lab: Sink or Float? Analysis: 1, 2, p. 165 Connections: Biomagnification and Bioaccumulation: 3, Section 5.3, p. 189 Chapter 5 Review: 26-30, p. 204-205 Unit 3 Review: 41-51, p. 248-251
20–C1.2sts explain that science and technology are influenced and supported by society and have influenced, and been influenced by, historical development and societal needs by ■ *comparing the ways in which concentrations of solutions are expressed in chemistry laboratories, household products and environmental studies*	Connections: Biomagnification and Bioaccumulation, Section 5.3, p. 189	Connections: Biomagnification and Bioaccumulation: 1-3, Section 5.3, p. 189 Chapter 5 Review: 26-30, p. 204-205 Unit 3 Review: 41-51, p. 248-251
20–C1.3sts explain that scientific and technological activity may arise from, and give rise to, such personal and social values as accuracy, honesty, perseverance, tolerance, open-mindedness, critical-mindedness, creativity and curiosity by ■ *explaining the Responsible Care® program developed by the Canadian Chemical Producers' Association*	Connections: Biomagnification and Bioaccumulation: 3, Section 5.3, p. 189 Investigation 5.C: Pollution of Waterways: A Risk-Benefit Analysis, Section 5.4, p. 199	Connections: Biomagnification and Bioaccumulation: 2, 3, Section 5.3, p. 189 Investigation 5.C: Pollution of Waterways: A Risk-Benefit Analysis: 1-6, Section 5.4, p. 199
20–C1.4sts explain how science and technology have both intended and unintended consequences for humans and the environment by ■ *explaining the significance of biomagnification in increasing the concentration of substances in the ecosystem*	Connections: Biomagnification and Bioaccumulation, Section 5.3, p. 189	Connections: Biomagnification and Bioaccumulation: 1, 2, Section 5.3, p. 189 Unit 3 Review: 41-51, p. 248-251

	Student Textbook	Assessment Options
20–C1.5sts explain that the appropriateness, risks and benefits of technologies need to be assessed for each potential application from a variety of perspectives, including sustainability by ■ *explaining the role of concentration in risk/benefit analysis for determining the safe limits of particular substances, e.g., pesticide residues, heavy metals, chlorinated or fluorinated compounds, pharmaceuticals.*	Thought Lab 5.1: Expressing Concentration, Section 5.3, p. 185 Connections: Biomagnification and Bioaccumulation, Section 5.3, p. 189	Thought Lab 5.1: Expressing Concentration, Analysis: 1, 2, Section 5.3, p. 185 Connections: Biomagnification and Bioaccumulation: 1, 2, Section 5.3, p. 189 Unit 3 Review: 41-51, p. 248-251
Skill Outcomes (Focus on decision making)		
Initiating and Planning		
20–C1.1s ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by ■ designing a procedure to identify the type of solution ■ designing a procedure for determining the concentration of a solution containing a solid solute ■ describing procedures for safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information.	Investigation 5.A; Classifying Solutions, Section 5.1, p. 174 Investigation 5.B: Plotting Solubility Curves, Section 5.2, p. 180 Thought Lab 5.1: Expressing Concentration, Section 5.3, p. 185 Investigation 5.D: Preparing and Diluting a Standard Solution, Section 5.4, p. 200	Investigation 5.A; Classifying Solutions, Analysis: 1-3, Conclusion:4, Extensions: 5, 6, Section 5.1, p. 174 Investigation 5.B: Plotting Solubility Curves, Analysis: 1-4, Conclusion: 5, Applications: 6, 7, Section 5.2, p. 181 Thought Lab 5.1: Expressing Concentration, Analysis: 1, 2, Section 5.3, p. 185 Investigation 5.D: Preparing and Diluting a Standard Solution, Extension: 3, 4, Section 5.4, p. 200
Performing and Recording		
20–C1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by ■ using a conductivity apparatus to classify solutions ■ performing an experiment to determine the concentration of a solution ■ using a balance and volumetric glassware to prepare solutions of specified concentration ■ performing an investigation to determine the solubility of a solute in a saturated solution.	Investigation 5.A; Classifying Solutions, Section 5.1, p. 174 Investigation 5.B: Plotting Solubility Curves, Section 5.2, p. 180 Investigation 5.D: Preparing and Diluting a Standard Solution, Section 5.4, p. 200	Investigation 5.A; Classifying Solutions, Analysis: 1-3, Conclusion:4, Extensions: 5, 6, Section 5.1, p. 174 Investigation 5.B: Plotting Solubility Curves, Analysis: 1-4, Conclusion: 5, Applications: 6, 7, Section 5.2, p. 181 Investigation 5.D: Preparing and Diluting a Standard Solution: 2-4, Section 5.4, p. 200
Analyzing and Interpreting		
20–C1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions by ■ using experimental data to determine the concentration of a solution ■ *evaluating the risks involved in safe handling, storage and disposal of solutions in common use in the laboratory and in the home.*	Investigation 5.D: Preparing and Diluting a Standard Solution, Section 5.4, p. 200 Investigation 5.C: Pollution of Waterways: A Risk-Benefit Analysis, Section 5.4, p. 199	Investigation 5.D: Preparing and Diluting a Standard Solution: 2, 4, Section 5.4, p. 200 Investigation 5.C: Pollution of Waterways: A Risk-Benefit Analysis: 3-6, Section 5.4, p. 199

	Student Textbook	Assessment Options
Communication and Teamwork		
20–C1.4s work as members of a team in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results by ■ comparing personal concentration data with the data of other groups ■ *selecting and using appropriate numeric, symbolic, graphical and linguistic modes of representation to communicate ideas, plans and results* ■ *using integrated software effectively and efficiently to incorporate data, graphics and text* ■ *collectively researching the risk/benefit issue of pollution of waterways by the release of effluents and proposing a plan for reducing the impact on the ecosystem.*	Investigation 5.B: Plotting Solubility Curves, Section 5.2, p. 180 Thought Lab 5.1: Expressing Concentration, Section 5.3, p. 185 Investigation 5.C: Pollution of Waterways: A Risk-Benefit Analysis: 2-6, Section 5.4, p. 199	Investigation 5.B: Plotting Solubility Curves, Analysis: 1-4, Conclusion: 5, Applications: 6, 7, Section 5.2, p. 181 Thought Lab 5.1: Expressing Concentration, Analysis: 1, 2, Section 5.3, p. 185 Investigation 5.C: Pollution of Waterways: A Risk-Benefit Analysis: 1-6, Section 5.4, p. 199

General Outcome 2: Students will describe acid and base solutions qualitatively and quantitatively.

	Student Textbook	Assessment Options
Outcomes for Knowledge		
20–C2.10k differentiate between strong acids and bases and weak acids and bases, qualitatively, on the basis of ionization and dissociation	Acids: Molecular Electrolytes, Section 5.1, p. 173	Section 5.1 Review: 6, p. 175
Outcomes for Science, Technology and Society (Emphasis on science and technology)		
20–C2.1sts explain that the goal of technology is to provide solutions to practical problems by ■ *relating the concept of pH to solutions encountered in everyday life, e.g., pharmaceuticals, shampoo and other cleaning products, aquatic and terrestrial environments, blood/blood products*	Connections: Biomagnification and Bioaccumulation, Section 5.3, p. 189	Connections: Biomagnification and Bioaccumulation: 3, Section 5.3, p. 189
20–C2.2sts explain that technological problems often have multiple solutions that involve different designs, materials and processes and have both intended and unintended consequences by ■ *providing examples of processes and products that use knowledge of acid and base chemistry, e.g., pulp and paper industry, food preparation and preservation, cleaning aids, sulfuric acid in car batteries, treating accidental acid or base spills using neutralization and dilution* ■ *explaining the significance of strength and concentration of solutions in everyday life, e.g., pharmaceuticals, chemical spills, transportation of dangerous goods, toxicity.*	Connections: Biomagnification and Bioaccumulation, Section 5.3, p. 189	Connections: Biomagnification and Bioaccumulation: 2, Section 5.3, p. 189

	Student Textbook	Assessment Options
Skill Outcomes (Focus on problem solving)		
Communication and Teamwork		
20–C2.4s work as members of a team in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results by ■ *collectively researching the relation between sulphuric acid and industrialization*	See Curriculum Correlation for Chapter 6	See Curriculum Correlation for Chapter 6
■ *assessing technologies used to reduce emissions leading to acid deposition*	Investigation 5.C: Pollution of Waterways: A Risk-Benefit Analysis: 2-6, Section 5.4, p. 199	Investigation 5.C: Pollution of Waterways: A Risk-Benefit Analysis: 1-6, Section 5.4, p. 199

CHAPTER 6 ACIDS AND BASES

Curriculum Correlation

General Outcome 2: Students will describe acid and base solutions qualitatively and quantitatively.

	Student Textbook	Assessment Options
Outcomes for Knowledge		
20–C2.1k recall nomenclature of acids and bases	Reviewing Naming Rules for Acids and Bases, Section 6.1, p. 209	Questions for Comprehension: 1, 2, Section 6.1, p. 209 Investigation 6.A: An Empirical Definition for Acids and Bases, Extension: 6, Section 6.1, p. 210 Section 6.2 Review: 2, 3, 6, p. 226 Chapter 6 Test
20–C2.2k recall the empirical definitions of acidic, basic and neutral solutions determined by using indicators, pH and conductivity	Empirical Definitions of Acids and Bases, Section 6.1, p. 210 Investigation 6.A: An Empirical Definition for Acids and Bases, Section 6.1, p. 210 Acids, Bases, and Conductivity, Section 6.1, p. 212	Investigation 6.A: An Empirical Definition for Acids and Bases, Analysis: 1, Conclusion: 4, Section 6.1, p. 210 Chapter 6 Review: 1, 2, 7, 14, p. 244-245 Chapter 6 Test Unit 3 Review: 14, 15, p. 248-251
20–C2.3k calculate $H_3O^+(aq)$ and $OH^-(aq)$ concentrations, pH and pOH of acidic and basic solutions based on logarithmic expressions, i.e. $pH = -\log[H_3O^+]$, $pOH = -\log[OH^-]$	Sample Problem: Calculating the pH of a Solution from $[H_3O^+(aq)]$, Section 6.3, p. 229 Sample Problem: Calculating the pH of a Solution, Section 6.3 p. 229 Investigation 6.E: The Effect of Dilution on the $[H_3O^+(aq)]$ and pH of an Acid, Section 6.3, p. 234 Sample Problem: Calculating the pOH of a Solution from $[OH^-(aq)]$, Section 6.3, p. 235 Sample Problem: Calculating the pOH of a Solution from Mass and Volume, Section 6.3, p. 236 Sample Problem: Calculating $[H_3O^+(aq)]$ from pH, Section 6.3, p. 240	Practice Problems: 1-6, Section 6.3, p. 230 Investigation 6.E: The Effect of Dilution on the $[H_3O^+(aq)]$ and pH of an Acid: 2-6, Section 6.3, p. 234 Practice Problems: 7-12, Section 6.3, p. 237 Practice Problems: 13-16, Section 6.3, p. 241 Section 6.3 Review: 4-9, p. 242 Chapter 6 Review: 11-14, 19, p. 244-245 Chapter 6 Test Unit 3 Review: 17, p. 248-251
20–C2.4k use appropriate SI units to communicate the concentration of solutions and express pH and concentration answers to the correct number of significant digits, i.e., use the number of decimal places in the pH to determine the number of significant digits of the concentration	Significant Digits and pH, Section 6.3, p. 228 Investigation 6.E: The Effect of Dilution on the $[H_3O^+(aq)]$ and pH of an Acid, Section 6.3, p. 234	Practice Problems: 1-6, Section 6.3, p. 230 Section 6.3 Review: 4-11, p. 242 Investigation 6.E: The Effect of Dilution on the $[H_3O^+(aq)]$ and pH of an Acid: 2-6, Section 6.3, p. 234 Throughout Chapter 6 Chapter 6 Test
20–C2.5k compare magnitude changes in pH and pOH with changes in concentration for acids and bases	Investigation 6.E: The Effect of Dilution on the $[H_3O^+(aq)]$ and pH of an Acid, Section 6.3, p. 234 The Relationship Between pH and pOH, Section 6.3, p. 237	Investigation 6.E: The Effect of Dilution on the $[H_3O^+(aq)]$ and pH of an Acid: 4-6, Section 6.3, p. 234 Practice Problems: 13-18, Section 6.3, p. 241 Section 6.3 Review: 8-13, p. 242 Chapter 6 Review: 11-13, p. 244-245 Chapter 6 Test Unit 3 Review: 26, p. 248-251

	Student Textbook	Assessment Options
20–C2.6k explain how the use of indicators, pH paper or pH meters can be used to measure [H_3O^+(aq)]	Chapter 6 Launch Lab: The Colour of Your Breath, p. 207 Investigation 6.A: An Empirical Definition for Acids and Bases, Section 6.1, p. 210-211 Indicators and Indicator Paper, Section 6.3, p. 231 Investigation 6.D: Determining the pH of an Unknown Solution with Indicators, Section 6.3, p. 232	Chapter 6 Launch Lab: The Colour of Your Breath, Analysis: 1-3, p. 207 Investigation 6.A: An Empirical Definition for Acids and Bases, Analysis: 1, 3, Extension: 5, 6, Section 6.1, p. 210-211 Investigation 6.D: Determining the pH of an Unknown Solution with Indicators: 1-3, Section 6.3, p. 232 Questions for Comprehension: 8-10, Section 6.3, p. 233 Section 6.3 Review: 3, p. 242 Chapter 6 Review: 8-10, 17, 18, 20, p. 244-245 Chapter 6 Test Unit 3 Review: 18-21, p. 248-251
20–C2.7k define Arrhenius (modified) acids as substances that produce H_3O^+(aq) in aqueous solutions	Investigation 6.A: An Empirical Definition for Acids and Bases, p. 210-211 Investigation 6.B: Testing the Arrhenius Theory of Acids and Bases, Section 6.1, p. 214 A Modified Theory, Section 6.1, p. 216-217	Investigation 6.A: An Empirical Definition for Acids and Bases, Analysis: 1, 2, Extension: 5, 6, Section 6.1, p. 210-211 Investigation 6.B: Testing the Arrhenius Theory of Acids and Bases: 1-4, Section 6.1, p. 214 Questions for Comprehension: 3, Section 6.1, p. 213 Section 6.1 Review: 3-5, p. 217 Questions for Comprehension: 5-7, Section 6.2, p. 222 Section 6.2 Review: 1, p. 226 Chapter 6 Review: 2, p. 244-245 Chapter 6 Test Unit 3 Review: 13, p. 248-251
20–C2.8k define Arrhenius (modified) bases as substances that produce OH^-(aq) in aqueous solutions	Investigation 6.A: An Empirical Definition for Acids and Bases, p. 210-211 Investigation 6.B: Testing the Arrhenius Theory of Acids and Bases, Section 6.1, p. 214 A Modified Theory, Section 6.1, p. 216-217	Investigation 6.A: An Empirical Definition for Acids and Bases, Analysis: 1, 2, Extension: 5, 6, Section 6.1, p. 210-211 Investigation 6.B: Testing the Arrhenius Theory of Acids and Bases: 1-4, Section 6.1, p. 214 Questions for Comprehension: 3, Section 6.1, p. 213 Section 6.1 Review: 3-5, p. 217 Questions for Comprehension: 5-7, Section 6.2, p. 222 Section 6.2 Review: 1, p. 226 Chapter 6 Review: 2, p. 244-245 Chapter 6 Test Unit 3 Review: 13, p. 248-251
20–C2.9k define neutralization as a reaction between hydronium and hydroxide ions	Neutralization, Section 6.2, p. 224	Section 6.2 Review: 6, p. 226 Chapter 6 Review: 3, 20, 30, p. 244-245 Chapter 6 Test

	Student Textbook	Assessment Options
20–C2.10k differentiate between strong acids and bases and weak acids and bases, qualitatively, on the basis of ionization and dissociation	Acids: Molecular Electrolytes, Section 5.1, p. 173 Strong and Weak Acids and Bases, Section 6.2, p. 218 Investigation 6.C: Differentiating between Weak and Strong Acids and Bases, Section 6.2, p. 221	Section 5.1 Review: 6, p. 17 Questions for Comprehension: 5-7, Section 6.2, p. 222 Investigation 6.C: Differentiating between Weak and Strong Acids and Bases: 1, 2, Section 6.2, p. 221 Section 6.2 Review: 2-5, p. 226 Chapter 6 Review: 4-6, 20, 22, p. 244 Chapter 6 Test Unit 3 Review: 15, 16, 21, 25, 49, p. 248-251
20–C2.11k compare the ionization of monoprotic with polyprotic acids and the dissociation/reaction with water of monoprotic with polyprotic bases, qualitatively.	Monoprotic and Polyprotic Acids, Section 6.2, p. 222, 223	Section 6.2 Review: 2, p. 226 Chapter 6 Review: 5, 6, p. 244-245 Chapter 6 Test
Outcomes for Science, Technology and Society (Emphasis on science and technology)		
20–C2.1sts explain that the goal of technology is to provide solutions to practical problems by ■ *relating the concept of pH to solutions encountered in everyday life, e.g., pharmaceuticals, shampoo and other cleaning products, aquatic and terrestrial environments, blood/blood products*	Connections: Biomagnification and Bioaccumulation, Section 5.3, p. 189 Chapter 6 Launch Lab: The Colour of Your Breath, p. 207	Connections: Biomagnification and Bioaccumulation: 3, Section 5.3, p. 189 Chapter 6 Launch Lab: The Colour of Your Breath, Analysis: 1-3, p. 207 Chapter 6 Review: 29-31, p. 244-245 Unit 3 Review: 41-51, p. 248-251
20–C2.2sts explain that technological problems often have multiple solutions that involve different designs, materials and processes and have both intended and unintended consequences by ■ *providing examples of processes and products that use knowledge of acid and base chemistry, e.g., pulp and paper industry, food preparation and preservation, cleaning aids, sulfuric acid in car batteries, treating accidental acid or base spills using neutralization and dilution* ■ *explaining the significance of strength and concentration of solutions in everyday life, e.g., pharmaceuticals, chemical spills, transportation of dangerous goods, toxicity.*	Connections: Biomagnification and Bioaccumulation, Section 5.3, p. 189 Thought Lab 6.1: Risks and Benefits of Transporting Acids and Bases, Section 6.2, p. 225	Connections: Biomagnification and Bioaccumulation: 2, Section 5.3, p. 189 Thought Lab 6.1: Risks and Benefits of Transporting Acids and Bases, Analysis: 1, Section 6.2, p. 225 Chapter 6 Review: 29-31, p. 244-245 Unit 3 Review: 41-51, p. 248-251

	Student Textbook	Assessment Options
Skill Outcomes (Focus on problem solving)		
Initiating and Planning		
20–C2.1s ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by ■ designing an experiment to differentiate among acidic, basic and neutral solutions	Investigation 6.A: An Empirical Definition for Acids and Bases, p. 210-211 Investigation 6.B: Testing the Arrhenius Theory of Acids and Bases, Section 6.1, p. 214 Investigation 6.C: Differentiating between Weak and Strong Acids and Bases, Section 6.2, p. 221 Investigation 6.E: The Effect of Dilution on the $[H_3O^+(aq)]$ and pH of an Acid, Section 6.3, p. 234	Investigation 6.A: An Empirical Definition for Acids and Bases, Analysis: 1, 2, Extension: 5, 6, Section 6.1, p. 210-211 Investigation 6.B: Testing the Arrhenius Theory of Acids and Bases: 2-4, Section 6.1, p. 214 Investigation 6.C: Differentiating between Weak and Strong Acids and Bases: 1, 2, Section 6.2, p. 221 Investigation 6.E: The Effect of Dilution on the $[H_3O^+(aq)]$ and pH of an Acid: 1, 2, 4, 6, Section 6.3, p. 234
■ designing an experiment to differentiate between weak and strong acids and between weak and strong bases	Investigation 6.A: An Empirical Definition for Acids and Bases, p. 210-211 Investigation 6.B: Testing the Arrhenius Theory of Acids and Bases, p. 214 Investigation 6.E: The Effect of Dilution on the $[H_3O^+(aq)]$ and pH of an Acid, Section 6.3, p. 234	Investigation 6.A: An Empirical Definition for Acids and Bases, Analysis: 1, 2, Extension: 5, 6, Section 6.1, p. 210-211 Investigation 6.B: Testing the Arrhenius Theory of Acids and Bases: 2-4, Section 6.1, p. 214 Investigation 6.E: The Effect of Dilution on the $[H_3O^+(aq)]$ and pH of an Acid: 2-4, 6, Section 6.3, p. 234
■ describing procedures for safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information.	Investigation 6.A: An Empirical Definition for Acids and Bases, p. 210-211 Investigation 6.B: Testing the Arrhenius Theory of Acids and Bases, p. 214 Thought Lab 6.1: Risks and Benefits of Transporting Acids and Bases, Section 6.2, p. 225 Investigation 6.E: The Effect of Dilution on the $[H_3O^+(aq)]$ and pH of an Acid, Section 6.3, p. 234	Investigation 6.A: An Empirical Definition for Acids and Bases, p. 210-211 Investigation 6.B: Testing the Arrhenius Theory of Acids and Bases: 2-4, Section 6.1, p. 214 Thought Lab 6.1: Risks and Benefits of Transporting Acids and Bases, Analysis: 1, Section 6.2, p. 225 Investigation 6.E: The Effect of Dilution on the $[H_3O^+(aq)]$ and pH of an Acid: 2-6, Section 6.3, p. 234
Performing and Recording		
20–C2.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by ■ constructing a table or graph to compare pH and hydronium ion concentration to illustrate that as the hydronium ion concentration increases, the pH decreases	Investigation 6.E: The Effect of Dilution on the $[H_3O^+(aq)]$ and pH of an Acid, Section 6.3, p. 234	Investigation 6.E: The Effect of Dilution on the $[H_3O^+(aq)]$ and pH of an Acid: 5, Section 6.3, p. 234
■ *using a pH meter to determine acidity and/or alkalinity of a solution.*	Investigation 6.E: The Effect of Dilution on the $[H_3O^+(aq)]$ and pH of an Acid, Section 6.3, p. 234	Investigation 6.E: The Effect of Dilution on the $[H_3O^+(aq)]$ and pH of an Acid: 1-6, Section 6.3, p. 234
Analyzing and Interpreting		
20–C2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions by ■ using indicators, determine the pH for a variety of solutions	Investigation 6.D: Determining the pH of an Unknown Solution with Indicators, Section 6.3, p. 232 Thought Lab 6.1: Risks and Benefits of Transporting Acids and Bases, Section 6.2, p. 225	Investigation 6.D: Determining the pH of an Unknown Solution with Indicators: 1-3, Section 6.3, p. 232 Thought Lab 6.1: Risks and Benefits of Transporting Acids and Bases, Analysis: 1, Section 6.2, p. 225
■ *assessing, qualitatively, the risks and benefits of producing, using and transporting acidic and basic substances, based on WHMIS and Transportation of Dangerous Goods guidelines.*		

	Student Textbook	Assessment Options
Communication and Teamwork		
20–C2.4s work as members of a team in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results by ■ *collectively researching the relation between sulfuric acid and industrialization* ■ *assessing technologies used to reduce emissions leading to acid deposition.*	Thought Lab 6.1: Risks and Benefits of Transporting Acids and Bases, Section 6.2, p. 225 Connections: Drain Cleaners, Section 6.3, p. 239 Career Focus: Ask a Marine Conservationist, p. 246 Investigation 5.C: Pollution of Waterways: A Risk-Benefit Analysis: 2-6, Section 5.4, p. 199	Thought Lab 6.1: Risks and Benefits of Transporting Acids and Bases, Analysis: 1, Section 6.2, p. 225 Connections: Drain Cleaners: 1, 2, Section 6.3, p. 239 Career Focus: Ask a Marine Conservationist: 1-3, p. 246 Investigation 5.C: Pollution of Waterways: A Risk-Benefit Analysis: 1-6, Section 5.4, p. 199

CHAPTER 7 STOICHIOMETRY

Curriculum Correlation

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

	Student Textbook	Assessment Options
Outcomes for Knowledge		
20–D1.1k predict the product(s) of a chemical reaction based upon the reaction type	Classifying Chemical Reactions, Unit 4 Preparation, p. 255 Predicting the Products of a Reaction, Unit 4 Preparation, p. 256 Chapter 7 Launch Lab: The Thermal Decomposition of Baking Soda, p. 261 Reactions in Aqueous Solution, Section 7.1, pp. 262-263, 264 Thought Lab 7.1: Identifying Unknown Aqueous Solutions, Section 7.1, p. 267 Investigation 7.A: Qualitative Analysis, Section 7.1, p. 268 Connections: Waste Water Treatment, Section 7.2, p. 279	Practice Problems: 1, 2, Unit 4 Preparation, p. 258 Chapter 7 Launch Lab: The Thermal Decomposition of Baking Soda, Analysis: 1, p. 261 Thought Lab 7.1: Identifying Unknown Aqueous Solutions, Section 7.1, Analysis 4, p. 267 Investigation 7.A: Qualitative Analysis, Analysis: 1-4, Section 7.1, p. 268 Connections: Waste Water Treatment: 1, 2, Section 7.2, p. 279 Chapter 7 Review: 9-11, p. 292-293 Chapter 7 Test Unit 4 Review: 6–9, 16, 17, 20, 25, 27, 30, 31, p. 328–331
20–D1.2k recall balancing of chemical equations in terms of atoms, molecules and moles	Guidelines for Balancing Chemical Equations, Unit 4 Preparation, p. 257 Sample Problem: Balancing Chemical Equations, Unit 4 Preparation, p. 258 Chapter 7 Launch Lab: The Thermal Decomposition of Baking Soda, p. 261 Reactions in Aqueous Solution, Section 7.1, pp. 262-263, 264 Stoichiometry and Qualitative Analysis, Section 7.2, p. 272-274 Connections: Waste Water Treatment, Section 7.2, p. 279	Practice Problems: 1, 2, Unit 4 Preparation, p. 258 Chapter 7 Launch Lab: The Thermal Decomposition of Baking Soda, Analysis: 1-3, p. 261 Section 7.1 Review: 8, p. 270 Connections: Waste Water Treatment: 1, 2, Section 7.2, p. 279 Chapter 7 Review: 7, p. 292-293 Chapter 7 Test Unit 4 Review: 1–4, 6–10, 15, 16, 23, 26, 33, p. 328–331

	Student Textbook	Assessment Options
20–D1.3k contrast quantitative and qualitative analysis	Qualitative versus Quantitative Analysis, Section 7.1, p. 265 Thought Lab: Identifying Unknown Aqueous Solutions, Section 7.1, p. 267 Stoichiometry and Qualitative Analysis, Section 7.2, p. 271	 Thought Lab: Identifying Unknown Aqueous Solutions: 1-4, Section 7.1, p. 267 Questions for Comprehension: 1, 2, Section 7.1, p. 268 Section 7.1 Review: 6, 7, 11, p. 270 Section 7.2 Review: 1, p. 289 Chapter 7 Review: 2, 6, 10, 19, p. 292-293 Chapter 7 Test Unit 4 Review: 20, p. 328–331
20–D1.4k write balanced ionic and net ionic equations, including identification of spectator ions, for reactions taking place in aqueous solutions	Reactions in Aqueous Solution, Section 7.1, pp. 262-263 Guidelines for Balancing Chemical Equations, Unit 4 Preparation, p. 257 Sample Problem: Balancing Chemical Equations, Unit 4 Preparation, p. 258 Sample Problem: Writing a Net Ionic Equation, Section 7.1, p. 264 Thought Lab 7.1: Identifying Unknown Aqueous Solutions, Section 7.1, p. 267 Investigation 7.A: Qualitative Analysis, Section 7.1, p. 268-269 Stoichiometry and Qualitative Analysis, Section 7.2, p. 272-274 Investigation 7.B: Determining the Concentration of a Solution, Section 7.2, p. 282	Practice Problems: 1, 2, Unit 4 Preparation, p. 258 Practice Problems: 1, 2, Section 7.1, p. 264 Thought Lab 7.1: Identifying Unknown Aqueous Solutions, Section 7.1, Analysis 4, p. 267 Investigation 7.A: Qualitative Analysis, Analysis: 1, 2, 5, 6, Section 7.1, p. 269 Section 7.1 Review: 1-3, 5, 8-10, p. 270 Investigation 7.B: Determining the Concentration of a Solution: 1-5, Section 7.2, p. 282 Section 7.2 Review: 2-4, p. 289 Chapter 7 Review: 1, 7, 8, p. 292-293 Chapter 7 Test Unit 4 Review: 1, 6–10, 14, 15, 17, 18, 20, 23, 26–28, 36–42, p. 328–331

	Student Textbook	Assessment Options
20–D1.5k calculate the quantities of reactants and/or products involved in chemical reactions using gravimetric, solution or gas stoichiometry.	Chapter 7 Launch Lab: The Thermal Decomposition of Baking Soda, p. 261 Stoichiometry and Qualitative Analysis, Section 7.2, p. 274-279, 284-287 Sample Problem: Gravimetric Stoichiometry: Reactant to Reactant, Section 7.2, p. 276 Sample Problem: Gravimetric Stoichiometry: Reactant to Product, Section 7.2, p. 277 Connections: Waste Water Treatment, Section 7.2, p. 279 Solution Stoichiometry, Section 7.2, p. 280 Sample Problem: Solution Stoichiometry, Section 7.2, p. 280 Investigation 7.B: Determining the Concentration of a Solution, Section 7.2, p. 282 Sample Problem: Gas Stoichiometry Using the Law of Combining Volumes, Section 7.2, p. 285 Sample Problem: Gas Stoichiometry Using the Ideal Gas Law, Section 7.2, p. 286 Acid-Base Titration, Section 8.3, pp. 315-316 Investigation 8.C: Standardizing a Hydrochloric Acid Solution, pp. 316-317	Chapter 7 Launch Lab: The Thermal Decomposition of Baking Soda, Analysis: 2, p. 261 Questions for Comprehension: 5, 6, Section 7.2, p. 275 Practice Problems: 8-15, Section 7.2, p. 278 Connections: Waste Water Treatment: 2, Section 7.2, p. 279 Questions for Comprehension: 7, Section 7.2, p. 280 Practice Problems: 16-19, Section 7.2, p. 282 Investigation 7.B: Determining the Concentration of a Solution: 1, 4, 5, Section 7.2, p. 282 Questions for Comprehension: 8, Section 7.2, p. 285 Practice Problems: 20-23, Section 7.2, p. 286 Questions for Comprehension: 9, Section 7.2, p. 286 Practice Problems: 24-27, Section 7.2, p. 287 Section 7.2 Review: 2-20, p. 289 Chapter 7 Review: 5, 12-22, p. 292-293 Chapter 7 Test Investigation 8.C: Standardizing a Hydrochloric Acid Solution, Analysis 1, p. 317 Unit 4 Review: 16, 23, 24, 26–29, 31, 32–42, p. 328–331

	Student Textbook	Assessment Options
Outcomes for Science, Technology and Society (Emphasis on social and environmental contexts)		
20–D1.1sts explain that the focus in technology is on the development of solutions, involving devices and systems that meet a given need within the constraints of a problem by ■ *analyzing the chemical reactions involved in various industrial and commercial processes and products that use stoichiometric and chemical principles, using examples from the following:* *– production of urea* *– fertilizers* *– fuel combustion* *– water treatment* *– air-bag deployment* *– neutralization of excess stomach acid.*	Connections: Waste Water Treatment, Section 7.2, p. 279 Investigation 7.C: Analyzing Industrial Processes, Section 7.2, p. 288	Connections: Waste Water Treatment: 1-4, Section 7.2, p. 279 Investigation 7.C: Analyzing Industrial Processes: 1-3, 1, 2, Section 7.2, p. 288 Chapter 7 Review: 19-22, p. 292-293 Unit 4 Review: 43–45, p. 328–331
Skill Outcomes (Focus on problem solving)		
Initiating and Planning		
20–D1.1s ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by ■ planning and predicting states, products and theoretical yields for chemical reaction ■ designing an experiment to identify an ion, e.g., *precipitation, flame test* ■ describing procedures for safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information.	Thought Lab: Identifying Unknown Aqueous Solutions, Section 7.1, p. 267 Investigation 7.B: Determining the Concentration of a Solution, Section 7.2, p. 282 Chapter 8, Launch Lab: The Model Air Bag, p. 295 Investigation 8.B: Determining the Percentage Yield of a Chemical Reaction, pp. 309-310	Thought Lab: Identifying Unknown Aqueous Solutions, Analysis: 1-4, Section 7.1, p. 267 Investigation 7.B: Determining the Concentration of a Solution: 1-5, Section 7.2, p. 282 Chapter 7 Review: 19-21, p. 292-293 Chapter 8, Launch Lab: The Model Air Bag, Analysis 2, p. 295 Investigation 8.B: Determining the Percentage Yield of a Chemical Reaction, Analysis 1-3, p. 310 Unit 4 Review: 11, 22, 43–45, p. 328–331
Performing and Recording		
20–D1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by ■ translating word equations for chemical reactions into chemical equations, including states of matter for the products and reactants ■ balancing chemical equations for chemical reactions, using lowest whole-number coefficients.	Thought Lab: Identifying Unknown Aqueous Solutions, Section 7.1, p. 267 Connections: Waste Water Treatment, Section 7.2, p. 279 Investigation 7.A: Qualitative Analysis, p. 273-274 Investigation 7.B: Determining the Concentration of a Solution, Section 7.2, p. 282	Thought Lab: Identifying Unknown Aqueous Solutions, Analysis: 1-4, Section 7.1, p. 267 Connections: Waste Water Treatment: 1, Section 7.2, p. 279 Investigation 7.A: Qualitative Analysis, Analysis 1, 2, p. 274 Investigation 7.B: Determining the Concentration of a Solution: 1-5, Section 7.2, p. 282

	Student Textbook	Assessment Options
Analyzing and Interpreting		
20–D1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions by ■ interpreting stoichiometric ratios from chemical reaction equations ■ performing calculations to determine theoretical yields ■ using appropriate SI notation, fundamental and derived units and significant digits when performing stoichiometric calculations.	Investigation 7.B: Determining the Concentration of a Solution, Section 7.2, p. 282 Throughout Chapter 7 Chapter 8, Launch Lab: The Model Air Bag, p. 295 Investigation 8.B: Determining the Percentage Yield of a Chemical Reaction, pp. 309-310	Investigation 7.B: Determining the Concentration of a Solution: 1-5, Section 7.2, p. 282 Throughout Chapter 7 Chapter 8, Launch Lab: The Model Air Bag, Analysis 1, p. 295 Investigation 8.B: Determining the Percentage Yield of a Chemical Reaction, Conclusion 4, Extension 5, pp. 309-310 Unit 4 Review: 19, 23–42, p. 328–331
Communication and Teamwork		
20–D1.4s work as members of a team in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results by ■ *using integrated software effectively and efficiently to incorporate data and text.*	Investigation 7.C: Analyzing Industrial Processes, Section 7.2, p. 288 Thought Lab 8.2: Plotting a Titration Curve, p. 320	Investigation 7.C: Analyzing Industrial Processes: 1-3, Section 7.2, p. 288 Section 7.2 Review: 8, p. 290 Thought Lab 8.2: Plotting a Titration Curve, Procedure 1, Analysis 5, p. 320

CHAPTER 8 APPLICATIONS OF STOICHIOMETRY

Curriculum Correlation

General Outcome 2: Students will use stoichiometry in quantitative analysis.

	Student Textbook	Assessment Options
Outcomes for Knowledge		
20–D2.1k explain chemical principles, i.e., conservation of mass in a chemical change, using quantitative analysis	Limiting and Excess Reactants, Section 8.1, p. 296 Investigation 8.B: Determining the Percentage Yield of a Chemical Reaction, Section 8.2, p. 309	Investigation 8.B: Determining the Percentage Yield of a Chemical Reaction, Extension: 5, Section 8.2, p. 309 Section 8.1 Review: 1, p. 304 Chapter 8 Review: 2, 3, p. 324-325 Chapter 8 Test Unit 4 Review: 1, 2, p. 328-331
20–D2.2k identify limiting and excess reagents in chemical reactions	Thought Lab 8.1: The Limiting Item, Section 8.1, p. 296 Limiting and Excess Reactants, Section 8.1, p. 296, 298-303 Limiting and Excess Reactants in Chemical Reactions, Section 8.1, p. 297 Sample Problem: Gravimetric Stoichiometry with a Limiting Reactant, Section 8.1, p. 298 Investigation 8.A: The Limiting Reactant, Section 8.1, p. 300 Sample Problem: Precipitating Mercury: A Limiting Reactant Problem, Section 8.1, p. 301 Sample Problem: Precipitating Silver Chromate, Section 8.1, p. 302 Investigation 8.B: Determining the Percentage Yield of a Chemical Reaction, Section 8.2, p. 309-310	Thought Lab 8.1: The Limiting Item: Analysis: 1-3, Section 8.1, p. 296 Questions for Comprehension: 1, Section 8.1, p. 297 Practice Problems: 1-6, Section 8.1, p. 299 Investigation 8.A: The Limiting Reactant, Analysis: 1, 2, Conclusion: 4, Extension: 5, Section 8.1, p. 300 Practice Problems: 7-12, Section 8.1, p. 302 Investigation 8.B: Determining the Percentage Yield of a Chemical Reaction, Analysis: 1, Section 8.2, p. 309-310 Section 8.1 Review: 1-8, p. 304 Chapter 8 Review: 1, 3, 11-15, p. 324-325 Chapter 8 Test Unit 4 Review: 23-42, p. 328-331

	Student Textbook	Assessment Options
20–D2.3k calculate theoretical yields and determine actual yields	Chapter 8 Launch Lab: The Model Air Bag, Analysis, p. 295 Sample Problem: Gravimetric Stoichiometry with a Limiting Reactant, Section 8.1, p. 298 Sample Problem: Precipitating Mercury: A Limiting Reactant Problem, Section 8.1, p. 301 Sample Problem: Precipitating Silver Chromate, Section 8.1, p. 302 Predicted and Exerpmental Yield, Section 8.2, pp 305-310 Sample Problem: Calculating the Percentage Yield, Section 8.2, p. 307 Investigation 8.B: Determining the Percentage Yield of a Chemical Reaction, Section 8.2, p. 309 Connections: Sulfur from Sour Gas, Section 8.3, p. 320	Chapter 8 Launch Lab: The Model Air Bag, Analysis: 1, 2, p. 295 Practice Problems: 1-6, Section 8.1, p. 299 Practice Problems: 7-12, Section 8.1, p. 302 Investigation 8.B: Determining the Percentage Yield of a Chemical Reaction, Analysis: 3, Extension: 4, 5, Section 8.2, p. 309 Connections: Sulfur from Sour Gas: 1, 2, Section 8.3, p. 320 Section 8.1 Review: 3-8, p. 304 Questions for Comprehension: 3, Section 8.2, p. 307 Practice Problems: 13-19, Section 8.2, p. 308 Section 8.2 Review: 1-8, p. 311 Chapter 8 Review: 15-17, p. 324-325 Chapter 8 Test Unit 4 Review: 35, 40-42, p. 328-331
20–D2.4k explain the discrepancy between theoretical and actual yields and calculate percent yield	Predicted and Experimental Yield, Section 8.2, p. 305, 308-309 Calculating the Percentage Yield of a Reaction, Section 8.2, p. 307 Investigation 8.B: Determining the Percentage Yield of a Chemical Reaction, Section 8.2, p. 309 Acid-Base Titration, Section 8.3, p. 312	Investigation 8.B: Determining the Percentage Yield of a Chemical Reaction, Analysis: 2, 3, Conclusion: 4, Extension: 5, Section 8.2, p. 309 Section 8.1 Review: 6, 7, p. 304 Questions for Comprehension: 2, 3, Section 8.2, p. 307 Practice Problems: 13-19, Section 8.2, p. 308 Section 8.2 Review: 1, 2, 7, 8, p. 311 Chapter 8 Review: 3-5, p. 324-325 Chapter 8 Test

	Student Textbook	Assessment Options
20–D2.5k draw and interpret titration curve graphs, using data from titration experiments involving strong monoprotic acids and strong monoprotic bases	Sample Problem: Determining Acid Concentration by Titration, Section 8.3, p. 314 Investigation 8.C: Standardizing a Hydrochloric Acid Solution, Section 8.3, p. 316 Acid-Base Titration Curves, Section 8.3, p. 317 Acid-Base Titration, Section 8.3, p. 318-319 Thought Lab 8.2: Plotting a Titration Curve, Section 8.3, p. 319	Practice Problems: 20-25, Section 8.3, p. 315 Investigation 8.C: Standardizing a Hydrochloric Acid Solution: 1-8, Section 8.3, p. 316 Thought Lab 8.2: Plotting a Titration Curve: 1-6, Section 8.3, p. 319 Questions for Comprehension: 8-10, Section 8.3, p. 319 Section 8.3 Review: 4, 6, p. 322 Chapter 8 Review: 10, 19, p. 324-325 Chapter 8 Test
20–D2.6k describe the function and choice of indicators in titrations	Acid-Base Titration, Section 8.3, p. 312 Investigation 8.C: Standardizing a Hydrochloric Acid Solution, Section 8.3, p. 316 Choosing an Indicator, Section 8.3, p. 318 Thought Lab 8.2: Plotting a Titration Curve, Section 8.3, p. 319 Investigation 8.D: Titrating a Strong Base with a Strong Acid, Section 8.3, p. 321	Investigation 8.C: Standardizing a Hydrochloric Acid Solution, Section 8.3, 1-8, p. 317 Thought Lab 8.2: Plotting a Titration Curve, Extension: 6, Section 8.3, p. 319 Investigation 8.D: Titrating a Strong Base with a Strong Acid: 7, Section 8.3, p. 321 Section 8.3 Review: 2, 6, p. 322 Chapter 8 Review: 6, 10, 19, pp. 324-325 Chapter 8 Test Unit 4 Review: 12, 35, p. 328-331
20–D2.7k identify equivalence points on strong monoprotic acid-strong monoprotic base titration curves and differentiate between the indicator endpoint and the equivalence point.	Acid-Base Titration, Section 8.3, p. 312, 319-320 Thought Lab 8.2: Plotting a Titration Curve, Section 8.3, p. 319 Investigation 8.D: Titrating a Strong Base with a Strong Acid, Section 8.3, p. 321	Questions for Comprehension: 9, 10, Section 8.3, p. 319 Thought Lab 8.2: Plotting a Titration Curve, Extension: 6, Section 8.3, p. 319 Investigation 8.D: Titrating a Strong Base with a Strong Acid: 6, 7, Section 8.3, p. 321 Section 8.3 Review: 2, 6, p. 322 Chapter 8 Review: 6, 8, 21, p. 324-325 Chapter 8 Test Unit 4 Review: 12, p. 328-331

	Student Textbook	Assessment Options
Outcomes for Science, Technology and Society (Emphasis on science and technology)		
20–D2.1sts explain that scientific knowledge may lead to the development of new technologies and that new technologies may lead to scientific discovery by ■ *describing how industries apply principles of stoichiometry to minimize waste and maximize yield*	Stoichiometry, Chapter 7 opener, p. 260 Reactions in Aqueous Solution, Section 7.1, p. 263 Stoiciometry and qualitative Analysis, Section 7.2, pp, 275, 279 Investigation 7.C: Analyzing Industrial Processes, Section 7.2, p. 288 Applications of Stoichiometry, Chapter 8 opener, p. 294 Chapter 8 Launch Lab: The Model Air Bag, p. 295 Predicted and Experimental Yield, Section 8.2, p. 307 Connections: Sulfur from Sour Gas, Section 8.3, p. 320	Investigation 7.C: Analyzing Industrial Processes: 1-3, 1, 2 Section 7.2, p. 288 Chapter 8 Launch Lab: The Model Air Bag, Analysis: 1, 2, p. 295 Connections: Sulfur from Sour Gas: 1-3, Section 8.3, p. 320 Chapter 8 Review: 3, 5, 21, p. 324-325 Unit 4 Review: 43-45, p. 328-331
20–D2.2sts explain how the appropriateness and the risks and benefits of technologies need to be assessed for each potential application from a variety of perspectives, including sustainability by ■ *assessing the significance of specific by-products from industrial, commercial and household applications of chemical reactions* ■ *analyzing the use of technology to reduce environmental impact in $SO_2(g)$ removal from smokestacks, catalytic converters in automobiles and reducing greenhouse gas emissions.*	Stoichiometry and Qualitative Analysis, Section 7.2, p. 279 Investigation 7.C: Analyzing Industrial Processes, Section 7.2, p. 288 Chapter 8 Launch Lab: The Model Air Bag, Analysis, p. 295 Connections: Sulfur from Sour Gas, Section 8.3, p. 320	Investigation 7.C: Analyzing Industrial Processes: 1-3, 1, 2 Section 7.2, p. 288 Chapter 8 Launch Lab: The Model Air Bag, Analysis: 1, 2, p. 295 Chapter 8 Review: 3, 5, 21, p. 324-325 Unit 4 Review: 43-45, p. 328-331 Connections: Sulfur from Sour Gas: 1-3, Section 8.3, p. 320
Skill Outcomes (Focus on problem solving)		
Initiating and Planning		
20–D2.1s ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by ■ designing a method using crystallization, filtration or titration to determine theconcentration of a solution ■ describing procedures for safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information ■ predicting the approximate equivalence point for a strong monoprotic acid-strong monoprotic base titration and selecting an appropriate indicator.	Investigation 8.C: Standardizing a Hydrochloric Acid Solution, Section 8.3, p. 316 Thought Lab 8.2: Plotting a Titration Curve, Section 8.3, p. 319 Investigation 8.D: Titrating a Strong Base with a Strong Acid, Section 8.3, p. 321	Section 8.1 Review: 8, p. 304 Investigation 8.C: Standardizing a Hydrochloric Acid Solution: 1-8, Section 8.3, p. 316 Thought Lab 8.2: Plotting a Titration Curve, Extension: 6, Section 8.3, p. 319 Investigation 8.D: Titrating a Strong Base with a Strong Acid: 1-7, Section 8.3, p. 321 Chapter 8 Review: 10, 24, p. 324-325 Unit 4 Review: 22, 45, p. 328-331

	Student Textbook	Assessment Options
Performing and Recording		
20–D2.2s conduct investigations into relationships between and among observable variables and use a broad range of tools and techniques to gather and record data and information by ■ performing a titration to determine the concentration of an acid or base restricted to strong monoprotic acid-strong monoprotic base combinations ■ *using probes and software to collect titration data* ■ *researching methods used by industry to reduce emissions* ■ *designing a prototype of a chemical industrial plant.*	Investigation 7.C: Analyzing Industrial Processes, Section 7.2, p. 288 Investigation 8.C: Standardizing a Hydrochloric Acid Solution, Section 8.3, p. 316 Thought Lab 8.2: Plotting a Titration Curve, Section 8.3, p. 319 Investigation 8.D: Titrating a Strong Base with a Strong Acid, Section 8.3, p. 321	Assessment Checklist 1: Designing an Experiment Investigation 8.C: Standardizing a Hydrochloric Acid Solution: 1-8, Section 8.3, p. 316 Thought Lab 8.2: Plotting a Titration Curve: 1-6, Section 8.3, p. 319 Investigation 8.D: Titrating a Strong Base with a Strong Acid: 1-8, Section 8.3, p. 321 Unit 4 Review: 22, 45, p. 328-331
Analyzing and Interpreting		
20–D2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions by ■ evaluating an experiment based on a precipitation reaction, to determine the concentration of a solution ■ creating and interpreting titration curve graphs for acid-base experiments restricted to strong monoprotic acid-strong monoprotic base combinations ■ calculating percent yield and explaining the discrepancies between the theoretical and actual yields ■ using appropriate SI notation, fundamental and derived units and significant digits when performing stoichiometric calculations	Investigation 8.C: Standardizing a Hydrochloric Acid Solution, Section 8.3, p. 316 Thought Lab 8.2: Plotting a Titration Curve, Section 8.3, p. 319 Investigation 8.D: Titrating a Strong Base with a Strong Acid, Section 8.3, p. 321	Investigation 8.C: Standardizing a Hydrochloric Acid Solution: 1-8, Section 8.3, p. 316 Thought Lab 8.2: Plotting a Titration Curve: 1-6, Section 8.3, p. 319 Assessment Checklist 1: Designing an Experiment
Communication and Teamwork		
20–D2.4s work as members of a team in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results by ■ standardizing an acid or base solution and comparing group results ■ *drawing a flowchart for an industrial chemical process* ■ *using integrated software effectively and efficiently to produce work that incorporates data, graphics and text.*	Investigation 7.C: Analyzing Industrial Processes, Section 7.2, p. 288 Investigation 8.C: Standardizing a Hydrochloric Acid Solution, Section 8.3, p. 316 Thought Lab 8.2: Plotting a Titration Curve, Section 8.3, p. 319	Assessment Checklist 4: Performance Task Group Assessment Investigation 8.C: Standardizing a Hydrochloric Acid Solution: 1-8, Section 8.3, p. 316 Thought Lab 8.2: Plotting a Titration Curve: 1-6, Section 8.3, p. 319

CHAPTER 9 ENERGY AND CHEMICAL REACTIONS

Curriculum Correlation

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

	Student Textbook	Assessment Options
Outcomes for Knowledge		
30–A1.1k recall the application of $Q = mc\Delta t$ to the analysis of energy transfer	**Measuring Thermal Energy Changes, Unit 5 Preparation, pp. 336–337** **Chapter 9 Launch Lab: Hot Packs and Cold Packs, p. 339**	**Practice Problems: 1–4, Unit 5 Preparation, p. 337** **Chapter 9 Launch Lab: Hot Packs and Cold Packs, Analysis: 1–3, p. 339** **Questions for Comprehension: 1, 2, Section 9.1, p. 342** **Section 9.1 Review: 1, p. 350** **Chapter 9 Review: 1, p. 366–377** **Chapter 9 Test** Unit 5 Review: 5, 7, pp. 424–427
30–A1.2k explain, in a general way, how stored energy in the chemical bonds of hydrocarbons originated from the Sun	**Enthalpy and Thermochemical Equations, Section 9.1, p. 340** **Enthalpy Changes of Endothermic Reactions, Section 9.1, p. 345**	**Section 9.1 Review: 2, p. 350** **Chapter 9 Review: 3, 15, p. 366–377** **Chapter 9 Test** Unit 5 Review: 1, 7, 20, pp. 424–427
30–A1.3k define enthalpy and molar enthalpy for chemical reactions	**Energy and Enthalpy, Section 9.1, p. 343** **Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Section 9.2, pp. 356–357**	**Questions for Comprehension: 3, 4, Section 9.1, p. 346** **Section 9.1 Review: 3–7, p. 350** **Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Analysis: 1, 2, 4, Conclusion: 5, Section 9.2, pp. 356–357** **Chapter 9 Review: 2, 14, p. 366–377** **Chapter 9 Test** Chapter 10 Review: 1, p. 401 Unit 5 Review: 4, 10, 24, 29, 30, 31, 36–43, pp. 424–427
30–A1.4k write balanced equations for chemical reactions that include energy changes	**Throughout Chapters 9, 10, and 11** **Energy Changes in Chemical Reactions, Section 9.1, p. 342** **Energy and Enthalpy, Section 9.1, p. 343**	**Questions for Comprehension: 3, 4, Section 9.1, p. 346** **Question for Comprehension: 5, Section 9.1, p. 347** **Section 9.1 Review: 3, 4, 6, 7, p. 350** **Chapter 9 Review: 5, 6, 12, 13, 23, 24, pp. 366–377** **Chapter 9 Test** Chapter 10 Review: 2, 18, p. 400–401 Unit 5 Review: 25, 32, 35, 41, 43, pp. 424–427

	Student Textbook	Assessment Options
30–A1.5k use and interpret ΔH notation to communicate energy changes and to calculate energy changes in chemical reactions	**Throughout Chapters 9, 10, and 11** **Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Section 9.2, pp. 356–357** **Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359** Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium, Section 10.1, pp. 375–377	**Section 9.1 Review: 3–7, p. 350** **Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Analysis: 4, Conclusion: 5, Section 9.2, pp. 356–357** **Investigation 9.B: Molar Enthalpy of Combustion, Part 1: 2, Part 2: 1, 2, Section 9.2, pp. 358–359** **Chapter 9 Review: 2–4, 6, 7, 13, 16–24, pp. 366–367** **Chapter 9 Test** Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium: 1–5, Section 10.1, pp. 375–377 Section 10.1 Review: 1–5, p. 383 Chapter 10 Review: 1, 2, 12, 15–26, pp. 400–401 Chapter 10 Test Unit 5 Review: 19, 25, 29–45, pp. 424–427
30–A1.6k predict the enthalpy change for chemical equations using standard enthalpies of formation	**Calculating Enthalpy Changes, Section 9.1, p. 348** **Sample Problem: Predicting an Enthalpy Change, Section 9.1, p. 348** **Sample Problem: Using Enthalpy Data to Determine the Mass of Products, Section 9.1, p. 349** Hess's Law, Section 10.1, p. 370 Sample Problem: Using Hess's Law to Determine Enthalpy Change for Formation Reactions, Section 10.1, p. 373 Standard Molar Enthalpies of Formation, Section 10.1, p. 377 Sample Problem: Using Enthalpies of Formation, Section 10.1, p. 381 Sample Problem: Using an Enthalpy of Combustion to Determine an Enthalpy of Formation, Section 10.1, p. 382	**Practice Problems: 1–6, Section 9.1, p. 349** **Chapter 9 Test** Practice Problems 1–6, Section 10.1, pp. 374–375 Questions for Comprehension: 1–3, Section 10.1, p. 378 Questions for Comprehension: 4–7, Section 10.1, p. 379 Practice Problems: 7–12, Section 10.1, pp. 382–383 Section 10.1 Review: 2, 3, 5, p. 383 Chapter 10 Review: 2, 3, 10, 15, 16, 18, pp. 400–401 Chapter 10 Test Unit 5 Review: 4, 25, 33, 39–41, 43, pp. 424–427
30–A1.7k explain and use Hess's law to calculate energy changes for a net reaction from a series of reactions	Hess's Law, Section 10.1, pp. 370–383 Sample Problem: Using Hess's Law to Determine Enthalpy Change, Section 10.1, p. 373 Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium, Section 10.1, pp. 375–377 Sample Problem: Using an Enthalpy of Combustion to Determine an Enthalpy of Formation, Section 10.1, p. 382	Practice Problems: 1–6, Section 10.1, pp. 374–375 Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium: 1–6, Section 10.1, pp. 375–377 Questions for Comprehension: 1–3, Section 10.1, p. 378 Practice Problems: 7–12, Section 10.1, pp. 382–383 Chapter 10 Review: 16, 18, 19, pp. 400–401 Chapter 10 Test Unit 5 Review: 25, 29, 37–39, pp. 424–427

	Student Textbook	Assessment Options
30–A1.8k use calorimetry data to determine the enthalpy changes in chemical reactions	**Calorimetry, Section 9.2, pp. 351–353** **Sample Problem: Determining the Enthalpy Change of a Reaction, Section 9.2, p. 354** **Connections: Energy for Living: How Food Fuels You, Section 9.1, pp. 361–362** **Sample Problem: Calculating Thermal Energy in a Bomb Calorimeter, Section 9.2, p. 362** Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium, Section 10.1, pp. 375–377	**Practice Problems: 7–12, Section 9.2, p. 355** **Questions for Comprehension: 7–10, Section 9.2, p. 355** **Practice Problems: 13–17, Section 9.2, p. 363** **Section 9.2 Review: 1–8, p. 364** **Chapter 9 Review: 4, 7–9, 11–13, 16–22, pp. 366–367** **Chapter 9 Test** Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium: 1–5, Section 10.1, pp. 375–377 Chapter 10 Review: 15, 24, 26, pp. 400–401 Chapter 10 Test Unit 5 Review: 11, 30, 32, 36, 44, pp. 424–427
30–A1.9k identify that liquid water and carbon dioxide gas are reactants for photosynthesis and are products for cellular respiration, in an open system, and that gaseous water and carbon dioxide gas are the products of hydrocarbon combustion	**Molar Enthalpy of Combustion, Section 9.1, p. 346** **Connections: Energy for Living: How Food Fuels You, Section 9.2, pp. 361–362**	**Web Link, Section 9.1, p. 347** **Questions for Comprehension: 5, 6, Section 9.1, p. 347** **Practice Problems: 2–4, Section 9.1, p. 349** **Chapter 9 Review: 5, 6, 10, 24, pp. 366-367** **Chapter 9 Test** Chapter 10 Review: 12, 15, 17, 20, 21, 23, 24, 26, 28, pp. 400–401 Unit 5 Review: 7, 8, 22, 24, 30, 32, 35, 42, 48, pp. 424–427
30–A1.10k classify chemical reactions, including those for the processes of photosynthesis, cellular respiration and hydrocarbon combustion as endothermic or exothermic.	**Describing Chemical Reactions, Unit 5 Preparation, p. 334** **Energy Changes in Chemical Reactions, Section 9.1, pp. 342–343** **Enthalpy Changes of Exothermic Reactions, Section 9.1, pp. 344–345** **Enthalpy Changes of Endothermic Reactions, Section 9.1, p. 345** **Molar Enthalpy of Combustion, Section 9.1, p. 346** **Connections: Energy for Living: How Food Fuels You, Section 9.2, pp. 361–362**	**Section 9.1 Review: 2, 5, p. 350** **Chapter 9 Review: 5, 6, 10, 15, 22, pp. 366-367** **Chapter 9 Test** Questions for Comprehension: 2, Section 10.1, p. 378 Unit 5 Review: 1, 3, 36, pp. 424–427

	Student Textbook	Assessment Options
Outcomes for Science, Technology and Society (Emphasis on science and technology)		
30–A1.1sts explain that the goal of technology is to provide solutions to practical problems by ■ *providing examples of personal reliance on the chemical potential energy of matter, e.g., the use of hydrocarbon fossil fuels* ■ *identifying ways to use energy more efficiently*	**Chapter 9 Launch Lab: Hot Packs and Cold Packs, p. 339** **Connections: Energy for Living: How Food Fuels You, Section 9.2, pp. 361–362** Chapter 10 Launch Lab: Bake a Cake, p. 368 Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium, Section 10.1, pp. 375–377 Thought Lab 10.1: Improving Energy Efficiency at Home, Section 10.2, p. 389 Connections: Efficient Home Heating, Section 10.2, p. 390 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 Connections: Car Pollution Solution? Inside a Catalytic Converter, Section 11.2, p. 414	**Chapter 9 Launch Lab: Hot Packs and Cold Packs, Analysis: 3, p. 339** **Connections: Energy for Living: How Food Fuels You: 1, 2, Section 9.2, pp. 361–362** Chapter 10 Launch Lab: Bake a Cake: 1–3, p. 368 Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium: 5, 6, Section 10.1, pp. 375–377 Thought Lab 10.1: Improving Energy Efficiency at Home: 1–4, Section 10.2, p. 389 Connections: Efficient Home Heating: 1, 2, Section 10.2, p. 390 Section 10.2 Review: 1–9, p. 392 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 Section 10.3 Review: 6, p. 398 Chapter 10 Review: 4–9, pp. 400–401 Connections: Car Pollution Solution? Inside a Catalytic Converter: 2, 3, Section 11.2, p. 414 Unit 5 Review: 46–49, pp. 424–427
30–A1.2sts demonstrate an understanding that technological problems often lend themselves to multiple solutions that involve different designs, materials and processes and have intended and unintended consequences by ■ *illustrating the applications of hydrocarbon fossil fuels, with examples from industries in Alberta.*	**Chapter 9 Launch Lab: Hot Packs and Cold Packs, p. 339** Investigation 10.B: Build a Heating Device, Section 10.2, pp. 387–388 Thought Lab 10.1: Improving Energy Efficiency at Home, Section 10.2, p. 389 Connections: Efficient Home Heating, Section 10.2, p. 390 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398	**Chapter 9 Launch Lab: Hot Packs and Cold Packs, Analysis: 2, p. 339** Investigation 10.B: Build a Heating Device: 1–3, Section 10.2, pp. 387–388 Thought Lab 10.1: Improving Energy Efficiency at Home: 1–4, Section 10.2, p. 389 Connections: Efficient Home Heating: 1, 2, Section 10.2, p. 390 Section 10.2 Review: 1–9, p. 392 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 Section 10.3 Review: 1–6, p. 398 Chapter 10 Review: 13, 14, pp. 400–401 Unit 5 Review: 46–49, p. 427

	Student Textbook	Assessment Options
Skill Outcomes (Focus on problem solving)		
Initiating and Planning		
30–A1.1s ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by ■ designing a method to compare the molar enthalpy change when burning two or more fuels, identifying and controlling major variables ■ describing procedures for safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information.	**Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359** Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium, Section 10.1, pp. 375–377 **Chapter 9 Launch Lab: Hot Packs and Cold Packs, p. 339** **Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359** Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium, Section 10.1, pp. 375–377	**Investigation 9.B: Molar Enthalpy of Combustion, Part 1: 1–4, Part 2: 1–4, Section 9.2, pp. 358–359** Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium: 1–6, Section 10.1, pp. 375–377 Unit 5 Review: 24, 47, pp. 424–427 **Chapter 9 Launch Lab: Hot Packs and Cold Packs, Analysis: 2, p. 339** **Investigation 9.B: Molar Enthalpy of Combustion, Part 1: 3, Part 2: 3, Section 9.2, pp. 358–359** Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium: 6, Section 10.1, pp. 375–377 Unit 5 Review: 24, 47, pp. 424–427
Performing and Recording		
30–A1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by ■ performing calorimetry experiments to determine the molar enthalpy change of chemical reactions ■ using thermometers or temperature probes appropriately when measuring temperature changes ■ *using a computer-based laboratory to compile and organize data from an experiment to demonstrate molar enthalpy change*	**Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Section 9.2, pp. 356–357** **Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359** Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium, Section 10.1, pp. 375–377 **Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359**	**Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Analysis: 1–4, Conclusion: 5, Section 9.2, pp. 356–357** **Investigation 9.B: Molar Enthalpy of Combustion, Part 1: 1–4, Part 2: 1–4, Section 9.2, pp. 358–359** Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium: 1–6, Section 10.1, pp. 375–377 Unit 5 Review: 24, 47, pp. 424–427 **Investigation 9.B: Molar Enthalpy of Combustion, Part 1: 2, Part 2: 3, Section 9.2, pp. 358–359**
■ *selecting and integrating information from various print and electronic sources to create multiple-linked documents on using alternative fuels.*	**Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359** **Connections: Energy for Living: How Food Fuels You, Section 9.2, Section 9.2, pp. 361–362** Investigation 10.B: Build a Heating Device, Section 10.2, pp. 387–388 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398	**Investigation 9.B: Molar Enthalpy of Combustion, Part 2: 3, Section 9.2, pp. 358–359** **Connections: Energy for Living: How Food Fuels You: 1–4, Section 9.2, pp. 361–362** Investigation 10.B: Build a Heating Device: 2, Section 10.2, pp. 387–388 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398

	Student Textbook	Assessment Options
Analyzing and Interpreting		
30–A1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions by ■ comparing energy changes associated with a variety of chemical reactions through the analysis of data and energy diagrams ■ *manipulating and presenting data through the selection of appropriate tools, e.g., scientific instrumentation, calculators, databases or spreadsheets.*	**Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359** Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium, Section 10.1, pp. 375–377 Investigation 10.B: Build a Heating Device, Section 10.2, pp. 387–388 **Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359** Investigation 10.B: Build a Heating Device, pp. 387–388 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398	**Investigation 9.B: Molar Enthalpy of Combustion, Part 1: 1, 2, Part 2: 1, 2, Section 9.2, pp. 358–359** Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium: 1–6, Section 10.1, pp. 375–377 Investigation 10.B: Build a Heating Device: 1–3, Section 10.2, pp. 387–388 Unit 5 Review: 11, 28, 35, 36–42, 44, pp. 424–427 **Investigation 9.B: Molar Enthalpy of Combustion, Part 2: 3, Section 9.2, pp. 358–359** Investigation 10.B: Build a Heating Device: 3, pp. 387–388 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 Unit 5 Review: 36, pp. 424–427
Communication and Teamwork		
30–A1.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results by ■ using appropriate International System of Units (SI) notation, fundamental and derived units for enthalpy changes and expressing molar enthalpies in kilojoules/mole ■ *using advanced menu features within a word processor to accomplish a task and to insert tables, graphs, text and graphics.*	**Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Section 9.2, pp. 356–357** **Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359** Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium, Section 10.1, pp. 375–377 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 **Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359** Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398	**Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Analysis: 1–3, Conclusion: 5, Section 9.2, pp. 356–357** **Investigation 9.B: Molar Enthalpy of Combustion, Part 1: 1–4, Part 2: 1–4, Section 9.2, pp. 358–359** Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium: 1–5, Section 10.1, pp. 375–377 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 **Investigation 9.B: Molar Enthalpy of Combustion, Part 2: 3, Section 9.2, pp. 358–359** Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 Chapter 10 Review: 27, p. 401

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

	Student Textbook	Assessment Options
Outcomes for Knowledge		
30–A2.1k define activation energy as the energy barrier that must be overcome for a chemical reaction to occur	Activation Energy, Section 11.1, p. 405	Questions for Comprehension: 1–3, Section 11.1, p. 407 Section 11.1 Review: 2, 4, 5, 7, 8, p. 410 Chapter 11 Review: 2, 3, 5, 6, 9, 14, 16, pp. 420–421 Chapter 11 Test Unit 5 Review: 16, 19, 45, pp. 424–427

	Student Textbook	Assessment Options
30–A2.2k explain the energy changes that occur during chemical reactions referring to bonds breaking and forming and changes in potential and kinetic energy	**Types of Energy, Section 9.1, p. 341** **Energy Changes in Chemical Reactions, Section 9.1, p. 342**	Section 11.1 Review: 1–3, p. 410 Chapter 11 Review: 1, 3, 5, 9, pp. 420–421 Unit 5 Review: 1, 6, 9, 20, pp. 424–427
30–A2.3k analyze and label energy diagrams for a chemical reaction, including reactants, products, enthalpy change and activation energy	**Enthalpy Changes of Exothermic Reactions, Section 9.1, pp. 344–345** **Enthalpy Changes of Endothermic Reactions, Section 9.1, p. 345** A Closer Look at a Molecular Collision, Section 11.1, p. 406 Sample Problem: Drawing a Potential Energy Diagram, Section 11.1, pp. 408–409	**Questions for Comprehension: 3, 4, Section 9.1, p. 346** Practice Problems: 1–5, Section 11.1, p. 409 Section 11.1 Review: 6–9, p. 410 Section 11.2 Review: 6, p. 418 Chapter 11 Review: 4, 6, 13–15, 18, 19, pp. 420–421 Chapter 11Test Unit 5 Review: 12, 19, 20, 29, 33, 43, 45, pp. 424–427
30–A2.4k explain that catalysts increase reaction rates by providing alternate pathways for changes without affecting the net amount of energy involved, e.g., *enzymes in living systems.*	Chapter 11 Launch Lab: Does It Gel? p. 403 Catalysts and Reaction Rates, Section 11.2, pp. 411–412 Try This, Section 11.2, p. 416 Investigation 11.A: The Effect of a Catalyst on the Decomposition of Hydrogen Peroxide, $H_2O_2(aq)$, Section 11.2, pp. 417–418	Chapter 11 Launch Lab: Does It Gel? Analysis: 3, p. 403 Questions for Comprehension: 1–3, Section 11.1, p. 407 Questions for Comprehension: 4, 5, Section 11.2, p. 413 Investigation 11.A: The Effect of a Catalyst on the Decomposition of Hydrogen Peroxide, $H_2O_2(aq)$: 1–6, Section 11.2, pp. 417–418 Section 11.2 Review: 1–6, p. 418 Chapter 11 Review: 7, 8, 10, 11, 12, 14, 17–29, p. 420–421 Chapter 11 Test Unit 5 Review: 18, 21, 29, 45, pp. 424–427

	Student Textbook	Assessment Options
Outcomes for Science, Technology and Society (Emphasis on science and technology)		
30–A2.1sts develop an understanding that the goal of technology is to provide solutions to practical problems by ■ e*xplaining how catalysts reduce air pollution from the burning of hydrocarbons; i.e., catalytic converters on cars*	**Chapter 9 Launch Lab: Hot Packs and Cold Packs, p. 339** Investigation 10.B: Build a Heating Device, Section 10.2, pp. 387–388 Thought Lab 10.1: Improving Energy Efficiency at Home, Section 10.2, p. 389 Connections: Efficient Home Heating, Section 10.2, p. 390 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 Chapter 11 Launch Lab: Does It Gel? p. 403 Connections: Car Pollution Solution? Inside a Catalytic Converter, Section 11.2, p. 414 Career Focus: Building Up and Breaking Down Bitumen, pp. 422–423	**Chapter 9 Launch Lab: Hot Packs and Cold Packs, Analysis: 1, 3, p. 339** Investigation 10.B: Build a Heating Device: 1–3, Section 10.2, pp. 387–388 Thought Lab 10.1: Improving Energy Efficiency at Home: 1–4, Section 10.2, p. 389 Connections: Efficient Home Heating: 1, 2, Section 10.2, p. 390 Section 10.2 Review: 1–9, p. 392 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 Section 10.3 Review: 1–6, p. 398 Chapter 11 Launch Lab: Does It Gel? Analysis: 2, 3, p. 403 Connections: Car Pollution Solution? Inside a Catalytic Converter: 1–3, Section 11.2, p. 414 Chapter 11 Review: 17, 22–29, pp. 420–421 Career Focus: Building Up and Breaking Down Bitumen, Go Further 1–3, pp. 422–423 Unit 5 Review: 46–49, pp. 424–427
30–A2.2sts identify the appropriateness, risks and benefits of technologies and the need to assess each potential application from a variety of perspectives, including sustainability by ■ *assessing qualitatively the risks and benefits of relying on fossil fuels as energy sources*	**Chapter 9 Launch Lab: Hot Packs and Cold Packs, p. 339** **Connections: Energy for Living: How Food Fuels You, Section 9.2, pp. 361–362** Chapter 10 Launch Lab: Bake a Cake, p. 368 Investigation 10.B: Build a Heating Device, Section 10.2, pp. 387–388 Thought Lab 10.1: Improving Energy Efficiency at Home, Section 10.2, p. 389 Connections: Efficient Home Heating, Section 10.2, p. 390 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398	**Chapter 9 Launch Lab: Hot Packs and Cold Packs, Analysis: 1–3, p. 339** **Connections: Energy for Living: How Food Fuels You: 1–4, Section 9.2, pp. 361–362** Chapter 10 Launch Lab: Bake a Cake: 1–3, p. 368 Investigation 10.B: Build a Heating Device: 1–3, Section 10.2, pp. 387–388 Thought Lab 10.1: Improving Energy Efficiency at Home: 1–4, Section 10.2, p. 389 Connections: Efficient Home Heating: 1, 2, Section 10.2, p. 390 Section 10.2 Review: 1–9, p. 392 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 Section 10.3 Review: 1–6, p. 398 Chapter 10 Review: 13, 14, p. 400 Chapter 11 Review: 17, 22–29, pp. 420–421 Unit 5 Review: 46–49, pp. 424–427

	Student Textbook	Assessment Options
30–A2.3sts explain that the products of technology are devices, systems and processes that meet given needs but that these products cannot solve all problems by ■ *evaluating the economic and environmental impact of different fuels by relating carbon dioxide emissions and the heat content of a fuel.*	Chapter 10 Launch Lab: Bake a Cake, p. 368 Investigation 10.B: Build a Heating Device, Section 10.2, pp. 387–388 Thought Lab 10.1: Improving Energy Efficiency at Home, Section 10.2, p. 389 Connections: Efficient Home Heating, Section 10.2, p. 390 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398	Chapter 10 Launch Lab: Bake a Cake: 3, p. 368 Investigation 10.B: Build a Heating Device: 1–3, Section 10.2, pp. 387–388 Thought Lab 10.1: Improving Energy Efficiency at Home: 1–4, Section 10.2, p. 389 Connections: Efficient Home Heating: 1, 2, Section 10.2, p. 390 Section 10.2 Review: 1–9, p. 392 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 Section 10.3 Review: 1–6, p. 398 Chapter 11 Review: 17, 22–29, pp. 420–421 Unit 5 Review: 46–49, pp. 424–427
Skill Outcomes (Focus on problem solving)		
Initiating and Planning		
30–A2.1s ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by ■ describing procedures for safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information ■ *designing an experimental procedure to illustrate the effect of a catalyst on a chemical reaction.*	Investigation 11.A: The Effect of a Catalyst on the Decomposition of Hydrogen Peroxide, $H_2O_2(aq)$, Section 11.2, pp. 417–418	Investigation 11.A: The Effect of a Catalyst on the Decomposition of Hydrogen Peroxide, $H_2O_2(aq)$: 1–6, Section 11.2, pp. 417–418 Unit 5 Review: 24, 27, pp. 424–425
Performing and Recording		
30–A2.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by ■ plotting energy graphs/enthalpy diagrams indicating changes in energy for chemical reactions ■ *using library and electronic research tools to compile information on the energy content of fuels used in Alberta power plants* ■ *designing and building a heating device.*	**Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359** Investigation 11.A: The Effect of a Catalyst on the Decomposition of Hydrogen Peroxide, $H_2O_2(aq)$, Section 11.2, pp. 417–418 **Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359** Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 **Chapter 9 Launch Lab: Hot Packs and Cold Packs, p. 339** Investigation 10.B: Build a Heating Device, Section 10.2, pp. 387–388	**Investigation 9.B: Molar Enthalpy of Combustion, Part 2: 2, Section 9.2, pp. 358–359** Investigation 11.A: The Effect of a Catalyst on the Decomposition of Hydrogen Peroxide, $H_2O_2(aq)$: 2, Section 11.2, pp. 417–418 **Investigation 9.B: Molar Enthalpy of Combustion, Part 2: 3, Section 9.2, pp. 358–359** Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 **Chapter 9 Launch Lab: Hot Packs and Cold Packs, Analysis: 1, 3, p. 339** Investigation 10.B: Build a Heating Device: 1–3, Section 10.2, pp. 387–388

	Student Textbook	Assessment Options
Analyzing and Interpreting		
30–A2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions by ■ interpreting an enthalpy diagram for a chemical reaction ■ explaining the discrepancy between the theoretical and actual efficiency of a thermal energy conversion system	**Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359** Chapter 10 Launch Lab: Bake a Cake, p. 368 Connections: Efficient Home Heating, Section 10.2, p. 390 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.2, p. 396	**Investigation 9.B: Molar Enthalpy of Combustion, Part 2: 3, Section 9.2, pp. 358–359** Unit 5 Review: 11, 28, 35, 36–42, 44, pp. 424–427 Chapter 10 Launch Lab: Bake a Cake: 2, 3, p. 368 Practice Problems: 13–16, Section 10.2, p. 387 Connections: Efficient Home Heating: 1, Section 10.2, p. 390 Section 10.2 Review: 1–9, p. 392 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Chapter 10 Review: 4–9, pp. 400–401 Chapter 11 Review: 4, 6, 13–15, 18, 19, pp. 420–421
■ *determining the efficiency of thermal energy conversion systems*	Chapter 10 Launch Lab: Bake a Cake, p. 368 Sample Problem: The Efficiency of a Propane Barbecue, Section 10.2, pp. 386–387 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.2, p. 396	Chapter 10 Launch Lab: Bake a Cake: 3, p. 368 Practice Problems: 13–16, Section 10.2, p. 387 Section 10.2 Review: 1–9, p. 392 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Chapter 10 Review: 4–9, pp. 400–401
■ *assessing whether coal or natural gas should be used to fuel thermal power plants in Alberta*	**Investigation 9.B: Molar Enthalpy of Combustion, Part 1: 1–4, Part 2: 1–4, Section 9.2, pp. 358–359** Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398	**Investigation 9.B: Molar Enthalpy of Combustion, Part 2: 3, Section 9.2, pp. 358–359** Section 10.2 Review: 1–9, p. 392 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 Section 10.3 Review: 1–6, p. 398 Chapter 10 Review: 13, 14, pp. 400
■ *evaluating a personally designed and constructed heating device, including a calculation of its efficiency.*	Investigation 10.B: Build a Heating Device, Section 10.2, pp. 387–388	Investigation 10.B: Build a Heating Device: 1–3, Section 10.2, pp. 387–388
Communication and Teamwork		
30–A2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results by ■ using appropriate SI notation, fundamental and derived units for calculating and communicating enthalpy changes	**Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Analysis: 1–4, Conclusions: 5, Section 9.2, pp. 356–357** **Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359** Investigation 10.B: Build a Heating Device, Section 10.2, pp. 387–388	**Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Analysis: 1–4, Conclusion: 5, Section 9.2, pp. 356–357** **Investigation 9.B: Molar Enthalpy of Combustion, Part 1: 1–4, Part 2: 1–4, Section 9.2, pp. 358–359** Investigation 10.B: Build a Heating Device: 1–3, Section 10.2, pp. 387–388
■ *working collaboratively to develop a plan to build an energy conversion device, seeking feedback, testing and reviewing the plan, making revisions and implementing the plan* ■ *using advanced menu features within a word processor to accomplish a task and to insert tables, graphs, text and graphics.*	**Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359** Investigation 10.B: Build a Heating Device: Section 10.2, pp. 387–388	**Investigation 9.B: Molar Enthalpy of Combustion, Part 2: 3, Section 9.2, pp. 358–359** Investigation 10.B: Build a Heating Device: 2, 3, Section 10.2, pp. 387–388 Chapter 10 Review: 27, p. 401

CHAPTER 10 THEORIES OF ENERGY AND CHEMICAL CHANGES

Curriculum Correlation

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

	Student Textbook	Assessment Options
Outcomes for Knowledge		
30–A1.1k recall the application of $Q = mc\Delta t$ to the analysis of energy transfer	Measuring Thermal Energy Changes, Unit 5 Preparation, pp. 336–337 Chapter 9 Launch Lab: Hot Packs and Cold Packs, p. 339	Practice Problems: 1–4, Unit 5 Preparation, p. 337 Chapter 9 Launch Lab: Hot Packs and Cold Packs, Analysis: 1–3, p. 339 Questions for Comprehension: 1, 2, Section 9.1, p. 342 Section 9.1 Review: 1, p. 350 Chapter 9 Review: 1, p. 366–377 Chapter 9 Test Unit 5 Review: 5, 7, pp. 424–427
30–A1.2k explain, in a general way, how stored energy in the chemical bonds of hydrocarbons originated from the Sun	Enthalpy and Thermochemical Equations, Section 9.1, p. 340 Enthalpy Changes of Endothermic Reactions, Section 9.1, p. 345	Section 9.1 Review: 2, p. 350 Chapter 9 Review: 3, 15, p. 366–377 Chapter 9 Test Unit 5 Review: 1, 7, 20, pp. 424–427
30–A1.3k define enthalpy and molar enthalpy for chemical reactions	Energy and Enthalpy, Section 9.1, p. 343 Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Section 9.2, pp. 356–357	Questions for Comprehension: 3, 4, Section 9.1, p. 346 Section 9.1 Review: 3–7, p. 350 Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Analysis: 1, 2, 4, Conclusion: 5, Section 9.2, pp. 356–357 Chapter 9 Review: 2, 14, p. 366–377 Chapter 9 Test **Chapter 10 Review: 1, p. 401** Unit 5 Review: 4, 10, 24, 29, 30, 31, 36–43, pp. 424–427
30–A1.4k write balanced equations for chemical reactions that include energy changes	**Throughout Chapters 9, 10, and 11** Energy Changes in Chemical Reactions, Section 9.1, p. 342 Energy and Enthalpy, Section 9.1, p. 343	Questions for Comprehension: 3, 4, Section 9.1, p. 346 Question for Comprehension: 5, Section 9.1, p. 347 Section 9.1 Review: 3, 4, 6, 7, p. 350 Chapter 9 Review: 5, 6, 12, 13, 23, 24, pp. 366–377 Chapter 9 Test **Chapter 10 Review: 2, 18, p. 400–401** Unit 5 Review: 25, 32, 35, 41, 43, pp. 424–427

	Student Textbook	Assessment Options
30–A1.5k use and interpret ΔH notation to communicate energy changes and to calculate energy changes in chemical reactions	Throughout Chapters 9, 10, and 11 Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Section 9.2, pp. 356–357 Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359 **Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium, Section 10.1, pp. 375–377**	Section 9.1 Review: 3–7, p. 350 Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Analysis: 4, Conclusion: 5, Section 9.2, pp. 356–357 Investigation 9.B: Molar Enthalpy of Combustion, Part 1: 2, Part 2: 1, 2, Section 9.2, pp. 358–359 Chapter 9 Review: 2–4, 6, 7, 13, 16–24, pp. 366–367 Chapter 9 Test **Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium: 1–5, Section 10.1, pp. 375–377** **Section 10.1 Review: 1–5, p. 383** **Chapter 10 Review: 1, 2, 12, 15–26, pp. 400–401** **Chapter 10 Test** Unit 5 Review: 19, 25, 29–45, pp. 424–427
30–A1.6k predict the enthalpy change for chemical equations using standard enthalpies of formation	Calculating Enthalpy Changes, Section 9.1, p. 348 Sample Problem: Predicting an Enthalpy Change, Section 9.1, p. 348 Sample Problem: Using Enthalpy Data to Determine the Mass of Products, Section 9.1, p. 349 **Hess's Law, Section 10.1, p. 370** **Sample Problem: Using Hess's Law to Determine Enthalpy Change for Formation Reactions, Section 10.1, p. 373** **Standard Molar Enthalpies of Formation, Section 10.1, p. 377** **Sample Problem: Using Enthalpies of Formation, Section 10.1, p. 381** **Sample Problem: Using an Enthalpy of Combustion to Determine an Enthalpy of Formation, Section 10.1, p. 382**	Practice Problems: 1–6, Section 9.1, p. 349 Chapter 9 Test **Practice Problems 1–6, Section 10.1, pp. 374–375** **Questions for Comprehension: 1–3, Section 10.1, p. 378** **Questions for Comprehension: 4–7, Section 10.1, p. 379** **Practice Problems: 7–12, Section 10.1, pp. 382–383** **Section 10.1 Review: 2, 3, 5, p. 383** **Chapter 10 Review: 2, 3, 10, 15, 16, 18, pp. 400–401** **Chapter 10 Test** Unit 5 Review: 4, 25, 33, 39–41, 43, pp. 424–427
30–A1.7k explain and use Hess's law to calculate energy changes for a net reaction from a series of reactions	**Hess's Law, Section 10.1, pp. 370–383** **Sample Problem: Using Hess's Law to Determine Enthalpy Change, Section 10.1, p. 373** **Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium, Section 10.1, pp. 375–377** **Sample Problem: Using an Enthalpy of Combustion to Determine an Enthalpy of Formation, Section 10.1, p. 382**	**Practice Problems: 1–6, Section 10.1, pp. 374–375** **Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium: 1–6, Section 10.1, pp. 375–377** **Questions for Comprehension: 1–3, Section 10.1, p. 378** **Practice Problems: 7–12, Section 10.1, pp. 382–383** **Chapter 10 Review: 16, 18, 19, pp. 400–401** **Chapter 10 Test** Unit 5 Review: 25, 29, 37–39, pp. 424–427

	Student Textbook	Assessment Options
30–A1.8k use calorimetry data to determine the enthalpy changes in chemical reactions	Calorimetry, Section 9.2, pp. 351–353 Sample Problem: Determining the Enthalpy Change of a Reaction, Section 9.2, p. 354 Connections: Energy for Living: How Food Fuels You, Section 9.1, pp. 361–362 Sample Problem: Calculating Thermal Energy in a Bomb Calorimeter, Section 9.2, p. 362 **Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium, Section 10.1, pp. 375–377**	Practice Problems: 7–12, Section 9.2, p. 355 Questions for Comprehension: 7–10, Section 9.2, p. 355 Practice Problems: 13–17, Section 9.2, p. 363 Section 9.2 Review: 1–8, p. 364 Chapter 9 Review: 4, 7–9, 11–13, 16–22, pp. 366–367 Chapter 9 Test **Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium: 1–5, Section 10.1, pp. 375–377** **Chapter 10 Review: 15, 24, 26, pp. 400–401** **Chapter 10 Test** Unit 5 Review: 11, 30, 32, 36, 44, pp. 424–427
30–A1.9k identify that liquid water and carbon dioxide gas are reactants for photosynthesis and are products for cellular respiration, in an open system, and that gaseous water and carbon dioxide gas are the products of hydrocarbon combustion	Molar Enthalpy of Combustion, Section 9.1, p. 346 Connections: Energy for Living: How Food Fuels You, Section 9.2, pp. 361–362	Web Link, Section 9.1, p. 347 Questions for Comprehension: 5, 6, Section 9.1, p. 347 Practice Problems: 2–4, Section 9.1, p. 349 Chapter 9 Review: 5, 6, 10, 24, pp. 366-367 Chapter 9 Test **Chapter 10 Review: 12, 15, 17, 20, 21, 23, 24, 26, 28, pp. 400–401** Unit 5 Review: 7, 8, 22, 24, 30, 32, 35, 42, 48, pp. 424–427
30–A1.10k classify chemical reactions, including those for the processes of photosynthesis, cellular respiration and hydrocarbon combustion as endothermic or exothermic.	Describing Chemical Reactions, Unit 5 Preparation, p. 334 Energy Changes in Chemical Reactions, Section 9.1, pp. 342–343 Enthalpy Changes of Exothermic Reactions, Section 9.1, pp. 344–345 Enthalpy Changes of Endothermic Reactions, Section 9.1, p. 345 Molar Enthalpy of Combustion, Section 9.1, p. 346 Connections: Energy for Living: How Food Fuels You, Section 9.2, pp. 361–362	Section 9.1 Review: 2, 5, p. 350 Chapter 9 Review: 5, 6, 10, 15, 22, pp. 366-367 Chapter 9 Test **Questions for Comprehension: 2, Section 10.1, p. 378** Unit 5 Review: 1, 3, 36, pp. 424–427

	Student Textbook	Assessment Options
Outcomes for Science, Technology and Society (Emphasis on science and technology)		
30–A1.1sts explain that the goal of technology is to provide solutions to practical problems by ■ *providing examples of personal reliance on the chemical potential energy of matter, e.g., the use of hydrocarbon fossil fuels* ■ *identifying ways to use energy more efficiently*	Chapter 9 Launch Lab: Hot Packs and Cold Packs, p. 339 Connections: Energy for Living: How Food Fuels You, Section 9.2, pp. 361–362 **Chapter 10 Launch Lab: Bake a Cake, p. 368** **Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium, Section 10.1, pp. 375–377** **Thought Lab 10.1: Improving Energy Efficiency at Home, Section 10.2, p. 389** **Connections: Efficient Home Heating, Section 10.2, p. 390** **Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396** **Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398** Connections: Car Pollution Solution? Inside a Catalytic Converter, Section 11.2, p. 414	Chapter 9 Launch Lab: Hot Packs and Cold Packs, Analysis: 3, p. 339 Connections: Energy for Living: How Food Fuels You: 1, 2, Section 9.2, pp. 361–362 **Chapter 10 Launch Lab: Bake a Cake: 1–3, p. 368** **Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium: 5, 6, Section 10.1, pp. 375–377** **Thought Lab 10.1: Improving Energy Efficiency at Home: 1–4, Section 10.2, p. 389** **Connections: Efficient Home Heating: 1, 2, Section 10.2, p. 390** **Section 10.2 Review: 1–9, p. 392** **Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396** **Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398** **Section 10.3 Review: 6, p. 398** **Chapter 10 Review: 4–9, pp. 400–401** Connections: Car Pollution Solution? Inside a Catalytic Converter: 2, 3, Section 11.2, p. 414 Unit 5 Review: 46–49, pp. 424–427
30–A1.2sts demonstrate an understanding that technological problems often lend themselves to multiple solutions that involve different designs, materials and processes and have intended and unintended consequences by ■ *illustrating the applications of hydrocarbon fossil fuels, with examples from industries in Alberta.*	Chapter 9 Launch Lab: Hot Packs and Cold Packs, p. 339 **Investigation 10.B: Build a Heating Device, Section 10.2, pp. 387–388** **Thought Lab 10.1: Improving Energy Efficiency at Home, Section 10.2, p. 389** **Connections: Efficient Home Heating, Section 10.2, p. 390** **Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396** **Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398**	Chapter 9 Launch Lab: Hot Packs and Cold Packs, Analysis: 2, p. 339 **Investigation 10.B: Build a Heating Device: 1–3, Section 10.2, pp. 387–388** **Thought Lab 10.1: Improving Energy Efficiency at Home: 1–4, Section 10.2, p. 389** **Connections: Efficient Home Heating: 1, 2, Section 10.2, p. 390** **Section 10.2 Review: 1–9, p. 392** **Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396** **Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398** **Section 10.3 Review: 1–6, p. 398** **Chapter 10 Review: 13, 14, pp. 400–401** Unit 5 Review: 46–49, p. 427

	Student Textbook	Assessment Options
Skill Outcomes (Focus on problem solving)		
Initiating and Planning		
30–A1.1s ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by ■ designing a method to compare the molar enthalpy change when burning two or more fuels, identifying and controlling major variables	Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359 **Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium, Section 10.1, pp. 375–377**	Investigation 9.B: Molar Enthalpy of Combustion, Part 1: 1–4, Part 2: 1–4, Section 9.2, pp. 358–359 **Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium: 1–6, Section 10.1, pp. 375–377** Unit 5 Review: 24, 47, pp. 424–427
■ describing procedures for safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information.	Chapter 9 Launch Lab: Hot Packs and Cold Packs, p. 339 Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359 **Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium, Section 10.1, pp. 375–377**	Chapter 9 Launch Lab: Hot Packs and Cold Packs, Analysis: 2, p. 339 Investigation 9.B: Molar Enthalpy of Combustion, Part 1: 3, Part 2: 3, Section 9.2, pp. 358–359 **Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium: 6, Section 10.1, pp. 375–377** Unit 5 Review: 24, 47, pp. 424–427
Performing and Recording		
30–A1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by ■ performing calorimetry experiments to determine the molar enthalpy change of chemical reactions	Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Section 9.2, pp. 356–357 Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359	Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Analysis: 1–4, Conclusion: 5, Section 9.2, pp. 356–357 Investigation 9.B: Molar Enthalpy of Combustion, Part 1: 1–4, Part 2: 1–4, Section 9.2, pp. 358–359
■ using thermometers or temperature probes appropriately when measuring temperature changes	**Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium, Section 10.1, pp. 375–377**	**Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium: 1–6, Section 10.1, pp. 375–377** Unit 5 Review: 24, 47, pp. 424–427
■ *using a computer-based laboratory to compile and organize data from an experiment to demonstrate molar enthalpy change*	Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359	Investigation 9.B: Molar Enthalpy of Combustion, Part 1: 2, Part 2: 3, Section 9.2, pp. 358–359
■ *selecting and integrating information from various print and electronic sources to create multiple-linked documents on using alternative fuels.*	Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359 Connections: Energy for Living: How Food Fuels You, Section 9.2, Section 9.2, pp. 361–362 **Investigation 10.B: Build a Heating Device, Section 10.2, pp. 387–388** **Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396** **Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398**	Investigation 9.B: Molar Enthalpy of Combustion, Part 2: 3, Section 9.2, pp. 358–359 Connections: Energy for Living: How Food Fuels You: 1–4, Section 9.2, pp. 361–362 **Investigation 10.B: Build a Heating Device: 2, Section 10.2, pp. 387–388** **Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396** **Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398**

	Student Textbook	Assessment Options
Analyzing and Interpreting		
30–A1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions by ■ comparing energy changes associated with a variety of chemical reactions through the analysis of data and energy diagrams	Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359 **Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium, Section 10.1, pp. 375–377** **Investigation 10.B: Build a Heating Device, Section 10.2, pp. 387–388**	Investigation 9.B: Molar Enthalpy of Combustion, Part 1: 1, 2, Part 2: 1, 2, Section 9.2, pp. 358–359 **Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium: 1–6, Section 10.1, pp. 375–377** **Investigation 10.B: Build a Heating Device: 1–3, Section 10.2, pp. 387–388** Unit 5 Review: 11, 28, 35, 36–42, 44, pp. 424–427
■ *manipulating and presenting data through the selection of appropriate tools, e.g., scientific instrumentation, calculators, databases or spreadsheets.*	Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359 **Investigation 10.B: Build a Heating Device, pp. 387–388** **Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398**	Investigation 9.B: Molar Enthalpy of Combustion, Part 2: 3, Section 9.2, pp. 358–359 **Investigation 10.B: Build a Heating Device: 3, pp. 387–388** **Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398** Unit 5 Review: 36, pp. 424–427
Communication and Teamwork		
30–A1.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results by ■ using appropriate International System of Units (SI) notation, fundamental and derived units for enthalpy changes and expressing molar enthalpies in kilojoules/mole	Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Section 9.2, pp. 356–357 Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359 **Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium, Section 10.1, pp. 375–377** **Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398**	Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Analysis: 1–3, Conclusion: 5, Section 9.2, pp. 356–357 Investigation 9.B: Molar Enthalpy of Combustion, Part 1: 1–4, Part 2: 1–4, Section 9.2, pp. 358–359 **Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium: 1–5, Section 10.1, pp. 375–377** **Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398**
■ *using advanced menu features within a word processor to accomplish a task and to insert tables, graphs, text and graphics.*	Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359 **Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398**	Investigation 9.B: Molar Enthalpy of Combustion, Part 2: 3, Section 9.2, pp. 358–359 **Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398** Chapter 10 Review: 27, p. 401

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

	Student Textbook	Assessment Options
Outcomes for Knowledge		
30–A2.1k define activation energy as the energy barrier that must be overcome for a chemical reaction to occur	Activation Energy, Section 11.1, p. 405	Questions for Comprehension: 1–3, Section 11.1, p. 407 Section 11.1 Review: 2, 4, 5, 7, 8, p. 410 Chapter 11 Review: 2, 3, 5, 6, 9, 14, 16, pp. 420–421 Chapter 11 Test Unit 5 Review: 16, 19, 45, pp. 424–427

	Student Textbook	Assessment Options
30–A2.2k explain the energy changes that occur during chemical reactions referring to bonds breaking and forming and changes in potential and kinetic energy	Types of Energy, Section 9.1, p. 341 Energy Changes in Chemical Reactions, Section 9.1, p. 342	Section 11.1 Review: 1–3, p. 410 Chapter 11 Review: 1, 3, 5, 9, pp. 420–421 Unit 5 Review: 1, 6, 9, 20, pp. 424–427
30–A2.3k analyze and label energy diagrams for a chemical reaction, including reactants, products, enthalpy change and activation energy	Enthalpy Changes of Exothermic Reactions, Section 9.1, pp. 344–345 Enthalpy Changes of Endothermic Reactions, Section 9.1, p. 345 A Closer Look at a Molecular Collision, Section 11.1, p. 406 Sample Problem: Drawing a Potential Energy Diagram, Section 11.1, pp. 408–409	Questions for Comprehension: 3, 4, Section 9.1, p. 346 Practice Problems: 1–5, Section 11.1, p. 409 Section 11.1 Review: 6–9, p. 410 Section 11.2 Review: 6, p. 418 Chapter 11 Review: 4, 6, 13–15, 18, 19, pp. 420–421 Chapter 11Test Unit 5 Review: 12, 19, 20, 29, 33, 43, 45, pp. 424–427
30–A2.4k explain that catalysts increase reaction rates by providing alternate pathways for changes without affecting the net amount of energy involved, e.g., *enzymes in living systems.*	Chapter 11 Launch Lab: Does It Gel? p. 403 Catalysts and Reaction Rates, Section 11.2, pp. 411–412 Try This, Section 11.2, p. 416 Investigation 11.A: The Effect of a Catalyst on the Decomposition of Hydrogen Peroxide, H_2O_2(aq), Section 11.2, pp. 417–418	Chapter 11 Launch Lab: Does It Gel? Analysis: 3, p. 403 Questions for Comprehension: 1–3, Section 11.1, p. 407 Questions for Comprehension: 4, 5, Section 11.2, p. 413 Investigation 11.A: The Effect of a Catalyst on the Decomposition of Hydrogen Peroxide, H_2O_2(aq): 1–6, Section 11.2, pp. 417–418 Section 11.2 Review: 1–6, p. 418 Chapter 11 Review: 7, 8, 10, 11, 12, 14, 17–29, p. 420–421 Chapter 11 Test Unit 5 Review: 18, 21, 29, 45, pp. 424–427

	Student Textbook	Assessment Options
Outcomes for Science, Technology and Society (Emphasis on science and technology)		
30–A2.1sts develop an understanding that the goal of technology is to provide solutions to practical problems by ■ e*xplaining how catalysts reduce air pollution from the burning of hydrocarbons; i.e., catalytic converters on cars*	Chapter 9 Launch Lab: Hot Packs and Cold Packs, p. 339 **Investigation 10.B: Build a Heating Device, Section 10.2, pp. 387–388** **Thought Lab 10.1: Improving Energy Efficiency at Home, Section 10.2, p. 389** **Connections: Efficient Home Heating, Section 10.2, p. 390** **Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396** **Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398** Chapter 11 Launch Lab: Does It Gel? p. 403 Connections: Car Pollution Solution? Inside a Catalytic Converter, Section 11.2, p. 414 Career Focus: Building Up and Breaking Down Bitumen, pp. 422–423	Chapter 9 Launch Lab: Hot Packs and Cold Packs, Analysis: 1, 3, p. 339 **Investigation 10.B: Build a Heating Device: 1–3, Section 10.2, pp. 387–388** **Thought Lab 10.1: Improving Energy Efficiency at Home: 1–4, Section 10.2, p. 389** **Connections: Efficient Home Heating: 1, 2, Section 10.2, p. 390** **Section 10.2 Review: 1–9, p. 392** **Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396** **Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398** **Section 10.3 Review: 1–6, p. 398** Chapter 11 Launch Lab: Does It Gel? Analysis: 2, 3, p. 403 Connections: Car Pollution Solution? Inside a Catalytic Converter: 1–3, Section 11.2, p. 414 Chapter 11 Review: 17, 22–29, pp. 420–421 Career Focus: Building Up and Breaking Down Bitumen, Go Further 1–3, pp. 422–423 Unit 5 Review: 46–49, pp. 424–427
30–A2.2sts identify the appropriateness, risks and benefits of technologies and the need to assess each potential application from a variety of perspectives, including sustainability by ■ *assessing qualitatively the risks and benefits of relying on fossil fuels as energy sources*	Chapter 9 Launch Lab: Hot Packs and Cold Packs, p. 339 Connections: Energy for Living: How Food Fuels You, Section 9.2, pp. 361–362 **Chapter 10 Launch Lab: Bake a Cake, p. 368** **Investigation 10.B: Build a Heating Device, Section 10.2, pp. 387–388** **Thought Lab 10.1: Improving Energy Efficiency at Home, Section 10.2, p. 389** **Connections: Efficient Home Heating, Section 10.2, p. 390** **Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396** **Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398**	Chapter 9 Launch Lab: Hot Packs and Cold Packs, Analysis: 1–3, p. 339 Connections: Energy for Living: How Food Fuels You: 1–4, Section 9.2, pp. 361–362 **Chapter 10 Launch Lab: Bake a Cake: 1–3, p. 368** **Investigation 10.B: Build a Heating Device: 1–3, Section 10.2, pp. 387–388** **Thought Lab 10.1: Improving Energy Efficiency at Home: 1–4, Section 10.2, p. 389** **Connections: Efficient Home Heating: 1, 2, Section 10.2, p. 390** **Section 10.2 Review: 1–9, p. 392** **Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396** **Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398** **Section 10.3 Review: 1–6, p. 398** **Chapter 10 Review: 13, 14, p. 400** Chapter 11 Review: 17, 22–29, pp. 420–421 Unit 5 Review: 46–49, pp. 424–427

	Student Textbook	Assessment Options
30–A2.3sts explain that the products of technology are devices, systems and processes that meet given needs but that these products cannot solve all problems by ■ *evaluating the economic and environmental impact of different fuels by relating carbon dioxide emissions and the heat content of a fuel.*	**Chapter 10 Launch Lab: Bake a Cake, p. 368** **Investigation 10.B: Build a Heating Device, Section 10.2, pp. 387–388** **Thought Lab 10.1: Improving Energy Efficiency at Home, Section 10.2, p. 389** **Connections: Efficient Home Heating, Section 10.2, p. 390** **Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396** **Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398**	**Chapter 10 Launch Lab: Bake a Cake: 3, p. 368** **Investigation 10.B: Build a Heating Device: 1–3, Section 10.2, pp. 387–388** **Thought Lab 10.1: Improving Energy Efficiency at Home: 1–4, Section 10.2, p. 389** **Connections: Efficient Home Heating: 1, 2, Section 10.2, p. 390** **Section 10.2 Review: 1–9, p. 392** **Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396** **Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398** **Section 10.3 Review: 1–6, p. 398** Chapter 11 Review: 17, 22–29, pp. 420–421 Unit 5 Review: 46–49, pp. 424–427
Skill Outcomes (Focus on problem solving)		
Initiating and Planning		
30–A2.1s ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by ■ describing procedures for safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information ■ *designing an experimental procedure to illustrate the effect of a catalyst on a chemical reaction.*	Investigation 11.A: The Effect of a Catalyst on the Decomposition of Hydrogen Peroxide, $H_2O_2(aq)$, Section 11.2, pp. 417–418	Investigation 11.A: The Effect of a Catalyst on the Decomposition of Hydrogen Peroxide, $H_2O_2(aq)$: 1–6, Section 11.2, pp. 417–418 Unit 5 Review: 24, 27, pp. 424–425
Performing and Recording		
30–A2.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by ■ plotting energy graphs/enthalpy diagrams indicating changes in energy for chemical reactions ■ *using library and electronic research tools to compile information on the energy content of fuels used in Alberta power plants* ■ *designing and building a heating device.*	Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359 Investigation 11.A: The Effect of a Catalyst on the Decomposition of Hydrogen Peroxide, $H_2O_2(aq)$, Section 11.2, pp. 417–418 Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359 **Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396** **Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398** Chapter 9 Launch Lab: Hot Packs and Cold Packs, p. 339 **Investigation 10.B: Build a Heating Device, Section 10.2, pp. 387–388**	Investigation 9.B: Molar Enthalpy of Combustion, Part 2: 2, Section 9.2, pp. 358–359 Investigation 11.A: The Effect of a Catalyst on the Decomposition of Hydrogen Peroxide, $H_2O_2(aq)$: 2, Section 11.2, pp. 417–418 Investigation 9.B: Molar Enthalpy of Combustion, Part 2: 3, Section 9.2, pp. 358–359 **Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396** **Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398** Chapter 9 Launch Lab: Hot Packs and Cold Packs, Analysis: 1, 3, p. 339 **Investigation 10.B: Build a Heating Device: 1–3, Section 10.2, pp. 387–388**

	Student Textbook	Assessment Options
Analyzing and Interpreting		
30–A2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions by ■ interpreting an enthalpy diagram for a chemical reaction ■ explaining the discrepancy between the theoretical and actual efficiency of a thermal energy conversion system	Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359 **Chapter 10 Launch Lab: Bake a Cake, p. 368** **Connections: Efficient Home Heating, Section 10.2, p. 390** **Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.2, p. 396**	Investigation 9.B: Molar Enthalpy of Combustion, Part 2: 3, Section 9.2, pp. 358–359 Unit 5 Review: 11, 28, 35, 36–42, 44, pp. 424–427 **Chapter 10 Launch Lab: Bake a Cake: 2, 3, p. 368** **Practice Problems: 13–16, Section 10.2, p. 387** **Connections: Efficient Home Heating: 1, Section 10.2, p. 390** **Section 10.2 Review: 1–9, p. 392** **Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396** **Chapter 10 Review: 4–9, pp. 400–401** Chapter 11 Review: 4, 6, 13–15, 18, 19, pp. 420–421
■ *determining the efficiency of thermal energy conversion systems*	**Chapter 10 Launch Lab: Bake a Cake, p. 368** **Sample Problem: The Efficiency of a Propane Barbecue, Section 10.2, pp. 386–387** **Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.2, p. 396**	**Chapter 10 Launch Lab: Bake a Cake: 3, p. 368** **Practice Problems: 13–16, Section 10.2, p. 387** **Section 10.2 Review: 1–9, p. 392** **Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396** **Chapter 10 Review: 4–9, pp. 400–401**
■ *assessing whether coal or natural gas should be used to fuel thermal power plants in Alberta*	Investigation 9.B: Molar Enthalpy of Combustion, Part 1: 1–4, Part 2: 1–4, Section 9.2, pp. 358–359 **Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396** **Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398**	Investigation 9.B: Molar Enthalpy of Combustion, Part 2: 3, Section 9.2, pp. 358–359 Section 10.2 Review: 1–9, p. 392 **Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396** **Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398** **Section 10.3 Review: 1–6, p. 398** **Chapter 10 Review: 13, 14, pp. 400**
■ *evaluating a personally designed and constructed heating device, including a calculation of its efficiency.*	**Investigation 10.B: Build a Heating Device, Section 10.2, pp. 387–388**	**Investigation 10.B: Build a Heating Device: 1–3, Section 10.2, pp. 387–388**
Communication and Teamwork		
30–A2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results by ■ using appropriate SI notation, fundamental and derived units for calculating and communicating enthalpy changes	Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Analysis: 1–4, Conclusions: 5, Section 9.2, pp. 356–357 Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359 **Investigation 10.B: Build a Heating Device, Section 10.2, pp. 387–388**	Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Analysis: 1–4, Conclusion: 5, Section 9.2, pp. 356–357 Investigation 9.B: Molar Enthalpy of Combustion, Part 1: 1–4, Part 2: 1–4, Section 9.2, pp. 358–359 **Investigation 10.B: Build a Heating Device: 1–3, Section 10.2, pp. 387–388**
■ *working collaboratively to develop a plan to build an energy conversion device, seeking feedback, testing and reviewing the plan, making revisions and implementing the plan* ■ *using advanced menu features within a word processor to accomplish a task and to insert tables, graphs, text and graphics.*	Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359 **Investigation 10.B: Build a Heating Device: Section 10.2, pp. 387–388**	Investigation 9.B: Molar Enthalpy of Combustion, Part 2: 3, Section 9.2, pp. 358–359 **Investigation 10.B: Build a Heating Device: 2, 3, Section 10.2, pp. 387–388** **Chapter 10 Review: 27, p. 401**

CHAPTER 11 ACTIVATION ENERGY AND CATALYSTS

Curriculum Correlation

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

	Student Textbook	Assessment Options
Outcomes for Knowledge		
30–A1.1k recall the application of $Q = mc\Delta t$ to the analysis of energy transfer	Measuring Thermal Energy Changes, Unit 5 Preparation, pp. 336–337 Chapter 9 Launch Lab: Hot Packs and Cold Packs, p. 339	Practice Problems: 1–4, Unit 5 Preparation, p. 337 Chapter 9 Launch Lab: Hot Packs and Cold Packs, Analysis: 1–3, p. 339 Questions for Comprehension: 1, 2, Section 9.1, p. 342 Section 9.1 Review: 1, p. 350 Chapter 9 Review: 1, p. 366–377 Chapter 9 Test Unit 5 Review: 5, 7, pp. 424–427
30–A1.2k explain, in a general way, how stored energy in the chemical bonds of hydrocarbons originated from the Sun	Enthalpy and Thermochemical Equations, Section 9.1, p. 340 Enthalpy Changes of Endothermic Reactions, Section 9.1, p. 345	Section 9.1 Review: 2, p. 350 Chapter 9 Review: 3, 15, p. 366–377 Chapter 9 Test Unit 5 Review: 1, 7, 20, pp. 424–427
30–A1.3k define enthalpy and molar enthalpy for chemical reactions	Energy and Enthalpy, Section 9.1, p. 343 Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Section 9.2, pp. 356–357	Questions for Comprehension: 3, 4, Section 9.1, p. 346 Section 9.1 Review: 3–7, p. 350 Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Analysis: 1, 2, 4, Conclusion: 5, Section 9.2, pp. 356–357 Chapter 9 Review: 2, 14, p. 366–377 Chapter 9 Test Chapter 10 Review: 1, p. 401 Unit 5 Review: 4, 10, 24, 29, 30, 31, 36–43, pp. 424–427
30–A1.4k write balanced equations for chemical reactions that include energy changes	**Throughout Chapters 9, 10, and 11** Energy Changes in Chemical Reactions, Section 9.1, p. 342 Energy and Enthalpy, Section 9.1, p. 343	Questions for Comprehension: 3, 4, Section 9.1, p. 346 Question for Comprehension: 5, Section 9.1, p. 347 Section 9.1 Review: 3, 4, 6, 7, p. 350 Chapter 9 Review: 5, 6, 12, 13, 23, 24, pp. 366–377 Chapter 9 Test Chapter 10 Review: 2, 18, p. 400–401 Unit 5 Review: 25, 32, 35, 41, 43, pp. 424–427

	Student Textbook	Assessment Options
30–A1.5k use and interpret ΔH notation to communicate energy changes and to calculate energy changes in chemical reactions	**Throughout Chapters 9, 10, and 11** Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Section 9.2, pp. 356–357 Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359 Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium, Section 10.1, pp. 375–377	Section 9.1 Review: 3–7, p. 350 Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Analysis: 4, Conclusion: 5, Section 9.2, pp. 356–357 Investigation 9.B: Molar Enthalpy of Combustion, Part 1: 2, Part 2: 1, 2, Section 9.2, pp. 358–359 Chapter 9 Review: 2–4, 6, 7, 13, 16–24, pp. 366–367 Chapter 9 Test Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium: 1–5, Section 10.1, pp. 375–377 Section 10.1 Review: 1–5, p. 383 Chapter 10 Review: 1, 2, 12, 15–26, pp. 400–401 Chapter 10 Test Unit 5 Review: 19, 25, 29–45, pp. 424–427
30–A1.6k predict the enthalpy change for chemical equations using standard enthalpies of formation	Calculating Enthalpy Changes, Section 9.1, p. 348 Sample Problem: Predicting an Enthalpy Change, Section 9.1, p. 348 Sample Problem: Using Enthalpy Data to Determine the Mass of Products, Section 9.1, p. 349 Hess's Law, Section 10.1, p. 370 Sample Problem: Using Hess's Law to Determine Enthalpy Change for Formation Reactions, Section 10.1, p. 373 Standard Molar Enthalpies of Formation, Section 10.1, p. 377 Sample Problem: Using Enthalpies of Formation, Section 10.1, p. 381 Sample Problem: Using an Enthalpy of Combustion to Determine an Enthalpy of Formation, Section 10.1, p. 382	Practice Problems: 1–6, Section 9.1, p. 349 Chapter 9 Test Practice Problems 1–6, Section 10.1, pp. 374–375 Questions for Comprehension: 1–3, Section 10.1, p. 378 Questions for Comprehension: 4–7, Section 10.1, p. 379 Practice Problems: 7–12, Section 10.1, pp. 382–383 Section 10.1 Review: 2, 3, 5, p. 383 Chapter 10 Review: 2, 3, 10, 15, 16, 18, pp. 400–401 Chapter 10 Test Unit 5 Review: 4, 25, 33, 39–41, 43, pp. 424–427
30–A1.7k explain and use Hess's law to calculate energy changes for a net reaction from a series of reactions	Hess's Law, Section 10.1, pp. 370–383 Sample Problem: Using Hess's Law to Determine Enthalpy Change, Section 10.1, p. 373 Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium, Section 10.1, pp. 375–377 Sample Problem: Using an Enthalpy of Combustion to Determine an Enthalpy of Formation, Section 10.1, p. 382	Practice Problems: 1–6, Section 10.1, pp. 374–375 Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium: 1–6, Section 10.1, pp. 375–377 Questions for Comprehension: 1–3, Section 10.1, p. 378 Practice Problems: 7–12, Section 10.1, pp. 382–383 Chapter 10 Review: 16, 18, 19, pp. 400–401 Chapter 10 Test Unit 5 Review: 25, 29, 37–39, pp. 424–427

	Student Textbook	Assessment Options
30–A1.8k use calorimetry data to determine the enthalpy changes in chemical reactions	Calorimetry, Section 9.2, pp. 351–353 Sample Problem: Determining the Enthalpy Change of a Reaction, Section 9.2, p. 354 Connections: Energy for Living: How Food Fuels You, Section 9.1, pp. 361–362 Sample Problem: Calculating Thermal Energy in a Bomb Calorimeter, Section 9.2, p. 362 Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium, Section 10.1, pp. 375–377	Practice Problems: 7–12, Section 9.2, p. 355 Questions for Comprehension: 7–10, Section 9.2, p. 355 Practice Problems: 13–17, Section 9.2, p. 363 Section 9.2 Review: 1–8, p. 364 Chapter 9 Review: 4, 7–9, 11–13, 16–22, pp. 366–367 Chapter 9 Test Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium: 1–5, Section 10.1, pp. 375–377 Chapter 10 Review: 15, 24, 26, pp. 400–401 Chapter 10 Test Unit 5 Review: 11, 30, 32, 36, 44, pp. 424–427
30–A1.9k identify that liquid water and carbon dioxide gas are reactants for photosynthesis and are products for cellular respiration, in an open system, and that gaseous water and carbon dioxide gas are the products of hydrocarbon combustion	Molar Enthalpy of Combustion, Section 9.1, p. 346 Connections: Energy for Living: How Food Fuels You, Section 9.2, pp. 361–362	Web Link, Section 9.1, p. 347 Questions for Comprehension: 5, 6, Section 9.1, p. 347 Practice Problems: 2–4, Section 9.1, p. 349 Chapter 9 Review: 5, 6, 10, 24, pp. 366-367 Chapter 9 Test Chapter 10 Review: 12, 15, 17, 20, 21, 23, 24, 26, 28, pp. 400–401 Unit 5 Review: 7, 8, 22, 24, 30, 32, 35, 42, 48, pp. 424–427
30–A1.10k classify chemical reactions, including those for the processes of photosynthesis, cellular respiration and hydrocarbon combustion as endothermic or exothermic.	Describing Chemical Reactions, Unit 5 Preparation, p. 334 Energy Changes in Chemical Reactions, Section 9.1, pp. 342–343 Enthalpy Changes of Exothermic Reactions, Section 9.1, pp. 344–345 Enthalpy Changes of Endothermic Reactions, Section 9.1, p. 345 Molar Enthalpy of Combustion, Section 9.1, p. 346 Connections: Energy for Living: How Food Fuels You, Section 9.2, pp. 361–362	Section 9.1 Review: 2, 5, p. 350 Chapter 9 Review: 5, 6, 10, 15, 22, pp. 366-367 Chapter 9 Test Questions for Comprehension: 2, Section 10.1, p. 378 Unit 5 Review: 1, 3, 36, pp. 424–427

	Student Textbook	Assessment Options
Outcomes for Science, Technology and Society (Emphasis on science and technology)		
30–A1.1sts explain that the goal of technology is to provide solutions to practical problems by ■ *providing examples of personal reliance on the chemical potential energy of matter, e.g., the use of hydrocarbon fossil fuels* ■ *identifying ways to use energy more efficiently*	Chapter 9 Launch Lab: Hot Packs and Cold Packs, p. 339 Connections: Energy for Living: How Food Fuels You, Section 9.2, pp. 361–362 Chapter 10 Launch Lab: Bake a Cake, p. 368 Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium, Section 10.1, pp. 375–377 Thought Lab 10.1: Improving Energy Efficiency at Home, Section 10.2, p. 389 Connections: Efficient Home Heating, Section 10.2, p. 390 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 **Connections: Car Pollution Solution? Inside a Catalytic Converter, Section 11.2, p. 414**	Chapter 9 Launch Lab: Hot Packs and Cold Packs, Analysis: 3, p. 339 Connections: Energy for Living: How Food Fuels You: 1, 2, Section 9.2, pp. 361–362 Chapter 10 Launch Lab: Bake a Cake: 1–3, p. 368 Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium: 5, 6, Section 10.1, pp. 375–377 Thought Lab 10.1: Improving Energy Efficiency at Home: 1–4, Section 10.2, p. 389 Connections: Efficient Home Heating: 1, 2, Section 10.2, p. 390 Section 10.2 Review: 1–9, p. 392 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 Section 10.3 Review: 6, p. 398 Chapter 10 Review: 4–9, pp. 400–401 **Connections: Car Pollution Solution? Inside a Catalytic Converter: 2, 3, Section 11.2, p. 414** Unit 5 Review: 46–49, pp. 424–427
30–A1.2sts demonstrate an understanding that technological problems often lend themselves to multiple solutions that involve different designs, materials and processes and have intended and unintended consequences by ■ *illustrating the applications of hydrocarbon fossil fuels, with examples from industries in Alberta.*	Chapter 9 Launch Lab: Hot Packs and Cold Packs, p. 339 Investigation 10.B: Build a Heating Device, Section 10.2, pp. 387–388 Thought Lab 10.1: Improving Energy Efficiency at Home, Section 10.2, p. 389 Connections: Efficient Home Heating, Section 10.2, p. 390 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398	Chapter 9 Launch Lab: Hot Packs and Cold Packs, Analysis: 2, p. 339 Investigation 10.B: Build a Heating Device: 1–3, Section 10.2, pp. 387–388 Thought Lab 10.1: Improving Energy Efficiency at Home: 1–4, Section 10.2, p. 389 Connections: Efficient Home Heating: 1, 2, Section 10.2, p. 390 Section 10.2 Review: 1–9, p. 392 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 Section 10.3 Review: 1–6, p. 398 Chapter 10 Review: 13, 14, pp. 400–401 Unit 5 Review: 46–49, p. 427

	Student Textbook	Assessment Options
Skill Outcomes (Focus on problem solving)		
Initiating and Planning		
30–A1.1s ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by ■ designing a method to compare the molar enthalpy change when burning two or more fuels, identifying and controlling major variables	Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359 Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium, Section 10.1, pp. 375–377	Investigation 9.B: Molar Enthalpy of Combustion, Part 1: 1–4, Part 2: 1–4, Section 9.2, pp. 358–359 Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium: 1–6, Section 10.1, pp. 375–377 Unit 5 Review: 24, 47, pp. 424–427
■ describing procedures for safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information.	Chapter 9 Launch Lab: Hot Packs and Cold Packs, p. 339 Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359 Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium, Section 10.1, pp. 375–377	Chapter 9 Launch Lab: Hot Packs and Cold Packs, Analysis: 2, p. 339 Investigation 9.B: Molar Enthalpy of Combustion, Part 1: 3, Part 2: 3, Section 9.2, pp. 358–359 Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium: 6, Section 10.1, pp. 375–377 Unit 5 Review: 24, 47, pp. 424–427
Performing and Recording		
30–A1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by ■ performing calorimetry experiments to determine the molar enthalpy change of chemical reactions ■ using thermometers or temperature probes appropriately when measuring temperature changes	Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Section 9.2, pp. 356–357 Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359 Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium, Section 10.1, pp. 375–377	Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Analysis: 1–4, Conclusion: 5, Section 9.2, pp. 356–357 Investigation 9.B: Molar Enthalpy of Combustion, Part 1: 1–4, Part 2: 1–4, Section 9.2, pp. 358–359 Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium: 1–6, Section 10.1, pp. 375–377 Unit 5 Review: 24, 47, pp. 424–427
■ *using a computer-based laboratory to compile and organize data from an experiment to demonstrate molar enthalpy change*	Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359	Investigation 9.B: Molar Enthalpy of Combustion, Part 1: 2, Part 2: 3, Section 9.2, pp. 358–359
■ *selecting and integrating information from various print and electronic sources to create multiple-linked documents on using alternative fuels.*	Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359 Connections: Energy for Living: How Food Fuels You, Section 9.2, Section 9.2, pp. 361–362 Investigation 10.B: Build a Heating Device, Section 10.2, pp. 387–388 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398	Investigation 9.B: Molar Enthalpy of Combustion, Part 2: 3, Section 9.2, pp. 358–359 Connections: Energy for Living: How Food Fuels You: 1–4, Section 9.2, pp. 361–362 Investigation 10.B: Build a Heating Device: 2, Section 10.2, pp. 387–388 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398

	Student Textbook	Assessment Options
Analyzing and Interpreting		
30–A1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions by ■ comparing energy changes associated with a variety of chemical reactions through the analysis of data and energy diagrams ■ *manipulating and presenting data through the selection of appropriate tools, e.g., scientific instrumentation, calculators, databases or spreadsheets.*	Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359 Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium, Section 10.1, pp. 375–377 Investigation 10.B: Build a Heating Device, Section 10.2, pp. 387–388 Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359 Investigation 10.B: Build a Heating Device, pp. 387–388 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398	Investigation 9.B: Molar Enthalpy of Combustion, Part 1: 1, 2, Part 2: 1, 2, Section 9.2, pp. 358–359 Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium: 1–6, Section 10.1, pp. 375–377 Investigation 10.B: Build a Heating Device: 1–3, Section 10.2, pp. 387–388 Unit 5 Review: 11, 28, 35, 36–42, 44, pp. 424–427 Investigation 9.B: Molar Enthalpy of Combustion, Part 2: 3, Section 9.2, pp. 358–359 Investigation 10.B: Build a Heating Device: 3, pp. 387–388 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 Unit 5 Review: 36, pp. 424–427
Communication and Teamwork		
30–A1.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results by ■ using appropriate International System of Units (SI) notation, fundamental and derived units for enthalpy changes and expressing molar enthalpies in kilojoules/mole ■ *using advanced menu features within a word processor to accomplish a task and to insert tables, graphs, text and graphics.*	Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Section 9.2, pp. 356–357 Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359 Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium, Section 10.1, pp. 375–377 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398	Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Analysis: 1–3, Conclusion: 5, Section 9.2, pp. 356–357 Investigation 9.B: Molar Enthalpy of Combustion, Part 1: 1–4, Part 2: 1–4, Section 9.2, pp. 358–359 Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium: 1–5, Section 10.1, pp. 375–377 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 Investigation 9.B: Molar Enthalpy of Combustion, Part 2: 3, Section 9.2, pp. 358–359 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 Chapter 10 Review: 27, p. 401

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

	Student Textbook	Assessment Options
Outcomes for Knowledge		
30–A2.1k define activation energy as the energy barrier that must be overcome for a chemical reaction to occur	**Activation Energy, Section 11.1, p. 405**	**Questions for Comprehension: 1–3, Section 11.1, p. 407** **Section 11.1 Review: 2, 4, 5, 7, 8, p. 410** **Chapter 11 Review: 2, 3, 5, 6, 9, 14, 16, pp. 420–421** **Chapter 11 Test** Unit 5 Review: 16, 19, 45, pp. 424–427

	Student Textbook	Assessment Options
30–A2.2k explain the energy changes that occur during chemical reactions referring to bonds breaking and forming and changes in potential and kinetic energy	Types of Energy, Section 9.1, p. 341 Energy Changes in Chemical Reactions, Section 9.1, p. 342	**Section 11.1 Review: 1–3, p. 410** **Chapter 11 Review: 1, 3, 5, 9, pp. 420–421** Unit 5 Review: 1, 6, 9, 20, pp. 424–427
30–A2.3k analyze and label energy diagrams for a chemical reaction, including reactants, products, enthalpy change and activation energy	Enthalpy Changes of Exothermic Reactions, Section 9.1, pp. 344–345 Enthalpy Changes of Endothermic Reactions, Section 9.1, p. 345 **A Closer Look at a Molecular Collision, Section 11.1, p. 406** **Sample Problem: Drawing a Potential Energy Diagram, Section 11.1, pp. 408–409**	Questions for Comprehension: 3, 4, Section 9.1, p. 346 **Practice Problems: 1–5, Section 11.1, p. 409** **Section 11.1 Review: 6–9, p. 410** **Section 11.2 Review: 6, p. 418** **Chapter 11 Review: 4, 6, 13–15, 18, 19, pp. 420–421** **Chapter 11Test** Unit 5 Review: 12, 19, 20, 29, 33, 43, 45, pp. 424–427
30–A2.4k explain that catalysts increase reaction rates by providing alternate pathways for changes without affecting the net amount of energy involved, e.g., *enzymes in living systems.*	**Chapter 11 Launch Lab: Does It Gel? p. 403** **Catalysts and Reaction Rates, Section 11.2, pp. 411–412** **Try This, Section 11.2, p. 416** **Investigation 11.A: The Effect of a Catalyst on the Decomposition of Hydrogen Peroxide, H_2O_2(aq), Section 11.2, pp. 417–418**	**Chapter 11 Launch Lab: Does It Gel? Analysis: 3, p. 403** **Questions for Comprehension: 1–3, Section 11.1, p. 407** **Questions for Comprehension: 4, 5, Section 11.2, p. 413** **Investigation 11.A: The Effect of a Catalyst on the Decomposition of Hydrogen Peroxide, H_2O_2(aq): 1–6, Section 11.2, pp. 417–418** **Section 11.2 Review: 1–6, p. 418** **Chapter 11 Review: 7, 8, 10, 11, 12, 14, 17–29, p. 420–421** **Chapter 11 Test** Unit 5 Review: 18, 21, 29, 45, pp. 424–427

	Student Textbook	Assessment Options
Outcomes for Science, Technology and Society (Emphasis on science and technology)		
30–A2.1sts develop an understanding that the goal of technology is to provide solutions to practical problems by ■ e*xplaining how catalysts reduce air pollution from the burning of hydrocarbons; i.e., catalytic converters on cars*	Chapter 9 Launch Lab: Hot Packs and Cold Packs, p. 339 Investigation 10.B: Build a Heating Device, Section 10.2, pp. 387–388 Thought Lab 10.1: Improving Energy Efficiency at Home, Section 10.2, p. 389 Connections: Efficient Home Heating, Section 10.2, p. 390 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 **Chapter 11 Launch Lab: Does It Gel? p. 403** **Connections: Car Pollution Solution? Inside a Catalytic Converter, Section 11.2, p. 414** Career Focus: Building Up and Breaking Down Bitumen, pp. 422–423	Chapter 9 Launch Lab: Hot Packs and Cold Packs, Analysis: 1, 3, p. 339 Investigation 10.B: Build a Heating Device: 1–3, Section 10.2, pp. 387–388 Thought Lab 10.1: Improving Energy Efficiency at Home: 1–4, Section 10.2, p. 389 Connections: Efficient Home Heating: 1, 2, Section 10.2, p. 390 Section 10.2 Review: 1–9, p. 392 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 Section 10.3 Review: 1–6, p. 398 **Chapter 11 Launch Lab: Does It Gel? Analysis: 2, 3, p. 403** **Connections: Car Pollution Solution? Inside a Catalytic Converter: 1–3, Section 11.2, p. 414** **Chapter 11 Review: 17, 22–29, pp. 420–421** Career Focus: Building Up and Breaking Down Bitumen, Go Further 1–3, pp. 422–423 Unit 5 Review: 46–49, pp. 424–427
30–A2.2sts identify the appropriateness, risks and benefits of technologies and the need to assess each potential application from a variety of perspectives, including sustainability by ■ *assessing qualitatively the risks and benefits of relying on fossil fuels as energy sources*	Chapter 9 Launch Lab: Hot Packs and Cold Packs, p. 339 Connections: Energy for Living: How Food Fuels You, Section 9.2, pp. 361–362 Chapter 10 Launch Lab: Bake a Cake, p. 368 Investigation 10.B: Build a Heating Device, Section 10.2, pp. 387–388 Thought Lab 10.1: Improving Energy Efficiency at Home, Section 10.2, p. 389 Connections: Efficient Home Heating, Section 10.2, p. 390 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398	Chapter 9 Launch Lab: Hot Packs and Cold Packs, Analysis: 1–3, p. 339 Connections: Energy for Living: How Food Fuels You: 1–4, Section 9.2, pp. 361–362 Chapter 10 Launch Lab: Bake a Cake: 1–3, p. 368 Investigation 10.B: Build a Heating Device: 1–3, Section 10.2, pp. 387–388 Thought Lab 10.1: Improving Energy Efficiency at Home: 1–4, Section 10.2, p. 389 Connections: Efficient Home Heating: 1, 2, Section 10.2, p. 390 Section 10.2 Review: 1–9, p. 392 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 Section 10.3 Review: 1–6, p. 398 Chapter 10 Review: 13, 14, p. 400 **Chapter 11 Review: 17, 22–29, pp. 420–421** Unit 5 Review: 46–49, pp. 424–427

	Student Textbook	Assessment Options
30–A2.3sts explain that the products of technology are devices, systems and processes that meet given needs but that these products cannot solve all problems by ■ *evaluating the economic and environmental impact of different fuels by relating carbon dioxide emissions and the heat content of a fuel.*	Chapter 10 Launch Lab: Bake a Cake, p. 368 Investigation 10.B: Build a Heating Device, Section 10.2, pp. 387–388 Thought Lab 10.1: Improving Energy Efficiency at Home, Section 10.2, p. 389 Connections: Efficient Home Heating, Section 10.2, p. 390 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398	Chapter 10 Launch Lab: Bake a Cake: 3, p. 368 Investigation 10.B: Build a Heating Device: 1–3, Section 10.2, pp. 387–388 Thought Lab 10.1: Improving Energy Efficiency at Home: 1–4, Section 10.2, p. 389 Connections: Efficient Home Heating: 1, 2, Section 10.2, p. 390 Section 10.2 Review: 1–9, p. 392 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 Section 10.3 Review: 1–6, p. 398 **Chapter 11 Review: 17, 22–29, pp. 420–421** Unit 5 Review: 46–49, pp. 424–427
Skill Outcomes (Focus on problem solving)		
Initiating and Planning		
30–A2.1s ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by ■ describing procedures for safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information ■ *designing an experimental procedure to illustrate the effect of a catalyst on a chemical reaction.*	**Investigation 11.A: The Effect of a Catalyst on the Decomposition of Hydrogen Peroxide, $H_2O_2(aq)$, Section 11.2, pp. 417–418**	**Investigation 11.A: The Effect of a Catalyst on the Decomposition of Hydrogen Peroxide, $H_2O_2(aq)$: 1–6, Section 11.2, pp. 417–418** Unit 5 Review: 24, 27, pp. 424–425
Performing and Recording		
30–A2.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by ■ plotting energy graphs/enthalpy diagrams indicating changes in energy for chemical reactions ■ *using library and electronic research tools to compile information on the energy content of fuels used in Alberta power plants* ■ *designing and building a heating device.*	Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359 **Investigation 11.A: The Effect of a Catalyst on the Decomposition of Hydrogen Peroxide, $H_2O_2(aq)$, Section 11.2, pp. 417–418** Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 Chapter 9 Launch Lab: Hot Packs and Cold Packs, p. 339 Investigation 10.B: Build a Heating Device, Section 10.2, pp. 387–388	Investigation 9.B: Molar Enthalpy of Combustion, Part 2: 2, Section 9.2, pp. 358–359 **Investigation 11.A: The Effect of a Catalyst on the Decomposition of Hydrogen Peroxide, $H_2O_2(aq)$: 2, Section 11.2, pp. 417–418** Investigation 9.B: Molar Enthalpy of Combustion, Part 2: 3, Section 9.2, pp. 358–359 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 Chapter 9 Launch Lab: Hot Packs and Cold Packs, Analysis: 1, 3, p. 339 Investigation 10.B: Build a Heating Device: 1–3, Section 10.2, pp. 387–388

	Student Textbook	Assessment Options
Analyzing and Interpreting		
30–A2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions by ■ interpreting an enthalpy diagram for a chemical reaction ■ explaining the discrepancy between the theoretical and actual efficiency of a thermal energy conversion system	Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359 Chapter 10 Launch Lab: Bake a Cake, p. 368 Connections: Efficient Home Heating, Section 10.2, p. 390 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.2, p. 396	Investigation 9.B: Molar Enthalpy of Combustion, Part 2: 3, Section 9.2, pp. 358–359 Unit 5 Review: 11, 28, 35, 36–42, 44, pp. 424–427 Chapter 10 Launch Lab: Bake a Cake: 2, 3, p. 368 Practice Problems: 13–16, Section 10.2, p. 387 Connections: Efficient Home Heating: 1, Section 10.2, p. 390 Section 10.2 Review: 1–9, p. 392 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Chapter 10 Review: 4–9, pp. 400–401 **Chapter 11 Review: 4, 6, 13–15, 18, 19, pp. 420–421**
■ *determining the efficiency of thermal energy conversion systems*	Chapter 10 Launch Lab: Bake a Cake, p. 368 Sample Problem: The Efficiency of a Propane Barbecue, Section 10.2, pp. 386–387 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.2, p. 396	Chapter 10 Launch Lab: Bake a Cake: 3, p. 368 Practice Problems: 13–16, Section 10.2, p. 387 Section 10.2 Review: 1–9, p. 392 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Chapter 10 Review: 4–9, pp. 400–401
■ *assessing whether coal or natural gas should be used to fuel thermal power plants in Alberta*	Investigation 9.B: Molar Enthalpy of Combustion, Part 1: 1–4, Part 2: 1–4, Section 9.2, pp. 358–359 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398	Investigation 9.B: Molar Enthalpy of Combustion, Part 2: 3, Section 9.2, pp. 358–359 Section 10.2 Review: 1–9, p. 392 Investigation 10.C: Fossil Fuels as Energy Sources: A Risk–Benefit Analysis, Section 10.3, p. 396 Investigation 10.D: Fuelling Thermal Power Plants, Section 10.3, p. 398 Section 10.3 Review: 1–6, p. 398 Chapter 10 Review: 13, 14, pp. 400
■ *evaluating a personally designed and constructed heating device, including a calculation of its efficiency.*	Investigation 10.B: Build a Heating Device, Section 10.2, pp. 387–388	Investigation 10.B: Build a Heating Device: 1–3, Section 10.2, pp. 387–388
Communication and Teamwork		
30–A2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results by ■ using appropriate SI notation, fundamental and derived units for calculating and communicating enthalpy changes	Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Analysis: 1–4, Conclusions: 5, Section 9.2, pp. 356–357 Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359 Investigation 10.B: Build a Heating Device, Section 10.2, pp. 387–388	Investigation 9.A: Determining the Enthalpy of a Neutralization Reaction, Analysis: 1–4, Conclusion: 5, Section 9.2, pp. 356–357 Investigation 9.B: Molar Enthalpy of Combustion, Part 1: 1–4, Part 2: 1–4, Section 9.2, pp. 358–359 Investigation 10.B: Build a Heating Device: 1–3, Section 10.2, pp. 387–388
■ *working collaboratively to develop a plan to build an energy conversion device, seeking feedback, testing and reviewing the plan, making revisions and implementing the plan* ■ *using advanced menu features within a word processor to accomplish a task and to insert tables, graphs, text and graphics.*	Investigation 9.B: Molar Enthalpy of Combustion, Section 9.2, pp. 358–359 Investigation 10.B: Build a Heating Device: Section 10.2, pp. 387–388	Investigation 9.B: Molar Enthalpy of Combustion, Part 2: 3, Section 9.2, pp. 358–359 Investigation 10.B: Build a Heating Device: 2, 3, Section 10.2, pp. 387–388 Chapter 10 Review: 27, p. 401

CHAPTER 12 OXIDATION-REDUCTION REACTIONS

Curriculum Correlation

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

	Student Textbook	Assessment Options
Outcomes for Knowledge		
30–B1.1k define oxidation and reduction operationally and theoretically	**Oxidation, Section 12.1, pp. 434–435** **Reduction, Section 12.1, p. 435** **Redox Reactions, Section 12.1, pp. 436–437**	**Questions for Comprehension: 1–4, Section 12.1, p. 437** **Section 12.1 Review: 1, 2, p. 440** **Chapter 12 Review: 4, p. 474** **Chapter 12 Test** Unit 6 Review: 1, 4, 6, 33, pp. 526–529
30–B1.2k define the following terms: oxidizing agent, reducing agent, oxidation number, half–reaction, disproportionation	**Reducing Iron Ore, Section 12.2, pp. 452–454** **Sample Problem: Assigning Oxidation Numbers, Section 12.3, pp. 457–458** **Balancing Equations Using the Oxidation Number Method, Section 12.3, p. 462**	**Questions for Comprehension: 1–4, Section 12.1, p. 437** **Section 12.1 Review: 1, 2, p. 440** **Chapter 12 Test** Unit 6 Review: 1, 4, 6, 33, pp. 526–529
30–B1.3k differentiate between oxidation–reduction (redox) reactions and other reactions using half–reactions and oxidation numbers	**Balancing Equations Using Half–Reactions, Section 12.1, pp. 443–445** **Balancing a Redox Equation in Basic Solution, Section 12.3, p. 463**	**Questions for Comprehension: 9–11, Section 12.2, p. 442** **Chapter 12 Test** Unit 6 Review: 1, 4–7, 11, 26, 29, 33–36, 44, | pp. 526–529
30–B1.4k identify electron transfer, oxidizing agents and reducing agents in redox reactions that occur in everyday life in both living and non–living systems, e.g., corrosion, *cellular respiration, photosynthesis*	**Redox Reactions, Section 12.1, p. 436** **Balancing Equations Using Half–Reactions, Section 12.2, p. 443** **Redox Reactions Involving Molecular Compounds, Section 12.2, pp. 454–456** **Sample Problem: Assigning Oxidation Numbers, Section 12.3, p. 457** **Quantitative Analysis of Redox Reactions, Section 12.4, p. 467–469** Fuel Cell History, Section 13.2, pp. 493–497 Corrosion Prevention, Section 13.2, pp. 499–502	**Questions for Comprehension: 3, Section 12.1, p. 437** **Section 12.1 Review: 7, p. 440** **Practice Problems: 1, 2, Section 12.2, p. 448** **Practice Problems: 12, 13, Section 12.3, p. 461** **Section 12.3 Review: 6, p. 466** **Chapter 12 Review: 1, 2, 5, 10, 21, pp. 474–475** **Chapter 12 Test** Questions for Comprehension: 4, 6, Section 13.1, p. 482 Section 13.2 Review: 1, p. 501 Chapter 13 Review: 7, 8, 16, pp. 522–523 Unit 6 Review: 2, 27, 36, 37, 44, 46, pp. 526–529
30–B1.5k compare the relative strengths of oxidizing and reducing agents from empirical data	**Investigation 12.A: Testing Relative Oxidizing and Reducing Strengths of Metal Atoms and Ions, Section 12.1 p. 438** **Predicting the Spontaneity of Redox Reactions, Section 12.1, pp. 439–440**	**Investigation 12.A: Testing Relative Oxidizing and Reducing Strengths of Metal Atoms and Ions: 1–4, Section 12.1 p. 438** **Questions for Comprehension: 5–8, Section 12.1, p. 440** **Chapter 12 Test**

	Student Textbook	Assessment Options
30–B1.6k predict the spontaneity of a redox reaction based on standard reduction potentials, and compare predictions to experimental results	**Spontaneity of Redox Reactions, Section 12.1, p. 437** **Predicting the Spontaneity of Redox Reactions, Section 12.1, p. 439**	**Questions for Comprehension: 5–8, Section 12.1, p. 440** **Section 12.1 Review: 5, 6, p. 440** **Chapter 12 Test** Chapter 13.3 Review: 3, p. 513 Chapter 13 Review: 11, pp. 522–523 Unit 6 Review: 3, 25, 38, pp. 526–529
30–B1.7k write and balance equations for redox reactions in acidic, basic and neutral solutions, including disproportionation reactions, by ■ using half–reaction equations obtained from a standard reduction potential table	**Writing Balanced Half–Reactions, Section 12.2, pp. 441–442** **Balancing Equations Using Half–Reactions, Section 12.2, pp. 442–443** **Balancing Equations for Reactions That Occur in Acidic or Basic Solutions, Section 12.2, pp. 444–445** **Sample Problem: Balancing an Equation for a Reaction That Occurs in an Acidic Solution, Section 12.2, p. 446** **Sample Problem: Balancing an Equation for a Reaction That Occurs in an Basic Solution, Section 12.2, pp. 447–448** **Disproportionation Reactions, Section 12.2, p. 450** **Sample Problem: Balancing a Disproportionation Reaction, Section 12.2, p. 451**	**Section 12.1 Review: 5, p. 440** **Questions for Comprehension: 9–11, Section 12.2, p. 442** **Practice Problems: 1, 2, Section 12.2, p. 448** **Practice Problems: 3–6, Section 12.2, p. 452** **Section 12.2 Review: 1–5, p. 454** **Section 12.3: 6, p. 466** **Practice Problems: 11–14, Section 12.3, p. 461** **Practice Problems: 22, Section 12.3, p. 469** **Chapter 12 Review: 1, 9, 10, 14–22, pp. 474–475** **Chapter 12 Test** Section 13.2 Review: 16, p. 501 Questions for Comprehension: 17, Section 13.3, p. 510 Section 13.4 Review: 6, p. 520 Chapter 13 Review: 6, p. 522 Unit 6 Review: 1, 8, 30, 34, 35, 37, 39, 46, p. 526–529
■ equations from information provided about redox changes **Note:** Students are expected to add water molecules, hydrogen ions and hydroxide ions to skeleton equations, as appropriate.	**Writing Balanced Half–Reactions, Section 12.2, pp. 441–442** **Balancing Equations Using Half–Reactions, Section 12.2, pp. 442–443** **Balancing Equations for Reactions That Occur in Acidic or Basic Solutions, Section 12.2, pp. 444–445** **Sample Problem: Balancing an Equation for a Reaction That Occurs in an Acidic Solution, Section 12.2, p. 446** **Sample Problem: Balancing an Equation for a Reaction That Occurs in an Basic Solution, Section 12.2, pp. 447–448**	**Questions for Comprehension: 9–11, Section 12.2, p. 442** **Practice Problems: 1, 2, Section 12.2, p. 448** **Section 12.2 Review: 1–5, p. 454** **Chapter 12 Review: 1, 14, pp. 474–475** **Chapter 12 Test** Questions for Comprehension: 5, 6, Section 13.1, p. 482 Practice Problems: 1–4, Section 13.1, p. 487 Questions for Comprehension: 13, Section 13.2, p. 500 Section 13.2 Review: 3, 8, 16, p. 501 Practice Problems: 5, Section 13.3, p. 508 Questions for Comprehension: 17, 18, Section 13.3, p. 510 Section 13.3 Review: 4, p. 513 Chapter 13 Review: 3, 6, 11, 13, 29, pp. 522–523 Unit 6 Review: 7, 11, 34, 36, 44, p. 526–529

	Student Textbook	Assessment Options
30–B1.7k (continued) ■ assigning oxidation numbers, where appropriate, to the species undergoing chemical change	**Assigning Oxidation Numbers, Section 12.3, pp. 455–456** **Sample Problem: Assigning Oxidation Numbers, Section 12.3, p. 457** **Applying Oxidation Numbers to Redox Reactions, Section 12.3, pp. 459–460**	**Practice Problems: 7–10, Section 12.3, p. 457** **Practice Problems: 15–18, Section 12.3, p. 464** **Section 12.3: 5–10, p. 466** **Chapter 12 Review: 3, 6, 7, 15, 20, pp. 474–475** **Chapter 12 Test** Unit 6 Review: 5–7, 35, pp. 526–529
30–B1.8k perform calculations to determine quantities of substances involved in redox titrations.	**Stoichiometry and Redox Titrations, Section 12.4, pp. 467–468** **Sample Problem: Redox Titrations, Section 12.4, pp. 468–469** **Investigation 12.C: Measuring the Concentration of Vitamin C in Orange Juice, Section 12.4, pp. 470–471**	**Practice Problems: 19–22, Section 12.4, p. 469** **Investigation 12.C: Measuring the Concentration of Vitamin C in Orange Juice: 1–8, Section 12.4, pp. 470–471** **Section 12.4 Review: 1–5, p. 472** **Chapter 12 Test** Unit 6 Review: 39, 40, pp. 526–529
Outcomes for Science, Technology and Society (Emphasis on science and technology)		
30–B1.1sts explain how the goal of technology is to provide solutions to practical problems by ■ *describing how the process of trial and error was used by early peoples to extract metals from their ores*	**Chapter 12 Launch Lab: Penny Chemistry, p. 433** **Investigation 12.A: Testing Relative Oxidizing and Reducing Strengths of Metal Atoms and Ions, Section 12.1, p. 438** **Connections: How Green Is White Paper? Section 12.3, p. 465**	**Chapter 12 Launch Lab: Penny Chemistry: 1–6, p. 433** **Investigation 12.A: Testing Relative Oxidizing and Reducing Strengths of Metal Atoms and Ions: 4, Section 12.1, p. 438** **Connections: How Green Is White Paper? 1–3, Section 12.3, p. 465** Unit 6 Review: 45–48, pp. 526–529
30–B1.2sts explain that technological problems often lend themselves to multiple solutions that involve different designs, materials and processes and have intended and unintended consequences by ■ *analyzing redox reactions used in industry and commerce, e.g., pulp and paper, textiles, water treatment, food processing.*	**Investigation 12.B: Redox Reactions and Balanced Equations, Section 12.2, pp. 448–450** **Connections: How Green Is White Paper? Section 12.3, p. 465**	**Investigation 12.B: Redox Reactions and Balanced Equations: 1–19, Section 12.2, pp. 448–450** **Connections: How Green Is White Paper? 1–3, Section 12.3, p. 465** Unit 6 Review: 45–48, pp. 526–529
Skill Outcomes (Focus on problem solving)		
Initiating and Planning		
30–B1.1s ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by ■ designing an experiment to determine the reactivity of various metals ■ describing procedures for safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information	**Investigation 12.B: Redox Reactions and Balanced Equations, Section 12.2, pp. 448–450**	**Investigation 12.B: Redox Reactions and Balanced Equations, Section 12.2: 1–19, pp. 448–450**

	Student Textbook	Assessment Options
Performing and Recording		
30–B1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by ■ selecting and correctly using the appropriate equipment to perform a redox titration experiment ■ using a standard reduction potential table as a tool in predicting the spontaneity of redox reactions and their products ■ *creating charts, tables or spreadsheets which present the results of redox experiments.*	**Investigation 12.C: Measuring the Concentration of Vitamin C in Orange Juice, Section 12.4, pp. 470–471** **Investigation 12.A: Testing Relative Oxidizing and Reducing Strengths of Metal Atoms and Ions, Section 12.1, p. 438**	**Investigation 12.C: Measuring the Concentration of Vitamin C in Orange Juice: 1–8, Section 12.4, pp. 470–471** **Investigation 12.A: Testing Relative Oxidizing and Reducing Strengths of Metal Atoms and Ions: 1–4, Section 12.1, p. 438** **Investigation 12.A: Testing Relative Oxidizing and Reducing Strengths of Metal Atoms and Ions: 3, Section 12.1, p. 438**
Analyzing and Interpreting		
30–B1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions by ■ evaluating data from an experiment to derive a simple reduction table ■ *interpreting patterns and trends in data derived from redox reactions* ■ *identifying the limitations of data collected.*	**Investigation 12.A: Testing Relative Oxidizing and Reducing Strengths of Metal Atoms and Ions, Section 12.1, p. 438** **Investigation 12.B: Redox Reactions and Balanced Equations, Section 12.2, pp. 448–450** **Thought Lab 12.1: Oxidation Numbers and Lewis Structures, Section 12.3, pp. 458–459**	**Investigation 12.A: Testing Relative Oxidizing and Reducing Strengths of Metal Atoms and Ions: 3, Section 12.1, p. 438** **Investigation 12.B: Redox Reactions and Balanced Equations: 1–19, Section 12.2, pp. 448–450** **Thought Lab 12.1: Oxidation Numbers and Lewis Structures, Section 12.3, pp. 458–459**
Communication and Teamwork		
30–B1.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results by ■ selecting and using appropriate numeric, symbolic, graphic and linguistic modes of representation to communicate equations for redox reactions and answers to problems related to redox titrations	**Investigation 12.B: Redox Reactions and Balanced Equations, Section 12.2, pp. 448–450** **Thought Lab 12.1: Oxidation Numbers and Lewis Structures, Section 12.3, pp. 458–459** **Investigation 12.C: Measuring the Concentration of Vitamin C in Orange Juice, Section 12.4, pp. 470–471**	**Investigation 12.B: Redox Reactions and Balanced Equations, Section 12.2: 1–19, pp. 448–450** **Thought Lab 12.1: Oxidation Numbers and Lewis Structures, Section 12.3, pp. 458–459** **Investigation 12.C: Measuring the Concentration of Vitamin C in Orange Juice: 1–8, Section 12.4, pp. 470–471**

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

	Student Textbook	Assessment Options
Outcomes for Knowledge		
30–B2.1k define anode, cathode, anion, cation, salt bridge/porous cup, electrolyte, external circuit, power supply, voltaic cell and electrolytic cell	The Voltaic Cell, Section 13.1, p. 478 Electrolytic Cells, Section 13.3, p. 502	Questions for Comprehension: 2, 3, Section 13.1, p. 480 Questions for Comprehension: 9, Section 13.2, p. 493 Chapter 13 Review: 1, pp. 522–523 Chapter 13 Test

	Student Textbook	Assessment Options
30–B2.2k identify the similarities and differences between the operation of a voltaic cell and that of an electrolytic cell	The Voltaic Cell, Section 13.1, p. 478 Electrolytic Cells, Section 13.3, p. 502	Questions for Comprehension: 2, 3, Section 13.1, p. 480 Questions for Comprehension: 8, 9, Section 13.2, p. 493 Section 13.2 Review: 9, p. 501 Chapter 13 Review: 1, 13, pp. 522–523 Chapter 13 Test Unit 6 Review: 13, 23, 24, 28, 32, pp. 526–529
30–B2.3k predict and write the half–reaction equation that occurs at each electrode in an electrochemical cell	Electrolytic Cells, Section 13.3, p. 502	Practice Problems: 5–8, Section 13.3, p. 508 Questions for Comprehension: 17–20, Section 13.3, p. 510 Chapter 13 Review: 13, 19, 20, pp. 522–523 Chapter 13 Test Unit 6 Review: 11, 31, 36, 44, pp. 526–529
30–B2.4k recognize that predicted reactions do not always occur, e.g., the production of chlorine gas from the electrolysis of brine	Predicting the Products of Electrolysis of Aqueous Solutions, Section 13.3, p. 507 Sample Problem: Electrolysis of an Aqueous Solution, Section 13.3, p. 507	Practice Problems 5–8, Section 13.3, p. 508 Questions for Comprehension: 17, 18, Section 13.3, p. 510 Chapter 13 Review: 5, 14, p. 513 Chapter 13 Test Unit 6 Review: 9, 17, 20, pp. 526–529
30–B2.5k explain that the values of standard reduction potential are all relative to zero volts set for the hydrogen electrode at standard conditions	Cell Potentials, Section 13.1, pp. 482–483	Thought Lab 13.1: Assigning Reference Values: 1–5, Section 13.1, p. 487 Section 13.1 Review: 5–7, p. 490 Questions for Comprehension: 13–16, Section 13.2, p. 500 Chapter 13 Review: 15, pp. 522–523 Chapter 13 Test Unit 6 Review: 9, 13, 23, 25, 31, pp. 526–529
30–B2.6k calculate the standard cell potential for electrochemical cells	Calculating Standard Cell Potentials, Section 13.1, pp. 485–486 Thought Lab 13.1: Assigning Reference Values: 1–5, Section 13.1, p. 487 Sample Problem: Calculating a Standard Cell Potential, Given a Net Ionic Equations, Section 13.1, p. 486 Sample Problem: Calculating a Standard Cell Potential, Given a Chemical Reaction, Section 13.1, pp. 486–487	Thought Lab 13.1: Assigning Reference Values: 1–5, Section 13.1, p. 487 Practice Problems: 1–4, Section 13.1, p. 487 Section 13.1 Review: 3–7, p. 490 Questions for Comprehension: 13, Section 13.2, p. 500 Chapter 13 Review: 6, 11, 12, 18, 21, pp. 522–523 Chapter 13 Test Unit 6 Review: 23, 28, 36, 38, pp. 526–529

	Student Textbook	Assessment Options
30–B2.7k predict the spontaneity or non–spontaneity of redox reactions based on standard cell potential and the relative positions of half–reaction equations on a standard reduction potential table	Predicting the Products of Electrolysis of Aqueous Solutions, Section 13.3, p. 507 Sample Problem: Electrolysis of an Aqueous Solution, Section 13.3, p. 507	**Questions for Comprehension: 5–8, Section 12.1, p. 440** **Section 12.1 Review; 3, 5, 6, p. 440** Practice Problems: 5-8, Section 13.3, p. 508 Section 13.3 Review: 3, p. 513 Chapter 13 Review: 11, pp. 522–523 Chapter 13 Test Unit 6 Review: 3, 38, pp. 526–529
30–B2.8k calculate mass, amounts, current and time in single voltaic and electrolytic cells by applying Faraday's law and stoichiometry.	Stoichiometry and Faraday's Law, Section 13.4, p. 514 Sample Problem: Calculating the Mass of an Electrolysis Product, Section 13.4, pp. 515–516 Faraday's law, Section 13.4, pp. 516–517	Practice Problems: 9–12, Section 13.4, p. 516 Section 13.4 Review: 1–6, p. 520 Chapter 13 Review: 16, 21–26, pp. 522–523 Chapter 13 Test Unit 6 Review: 41–43,, pp. 526–529
Outcomes for Science, Technology and Society (Emphasis on science and technology)		
30–B2.1sts describe the ways in which scientific knowledge may lead to the development of new technologies and new technologies may lead to scientific discoveries by ■ *analyzing the relationship of scientific knowledge and technological development in the applications of voltaic and electrolytic cells for, e.g., batteries, electroplating, refining metals from ores, electrowinning, sanitizing swimming pools with chlorine compounds*	**Connections: How Green Is White Paper? Section 12.3, p. 465** Chapter 13 Launch Lab: What Determines Voltage? p. 477	**Connections: How Green Is White Paper? 1–3, Section 12.3, p. 465** Chapter 13 Launch Lab: What Determines Voltage? 1–5, p. 477 Unit 6 Review: 45–48, pp. 526–529
30–B2.2sts describe applications of science and technology that have developed in response to human and environmental needs by ■ *investigating the use of technology to solve practical problems related to corrosion; e.g., galvanizing, metallurgy, magnesium coupling, painting*	**Chapter 12 Launch Lab: Penny Chemistry, p. 433** **Connections: How Green Is White Paper? Section 12.3, p. 465** Chapter 13 Launch Lab: What Determines Voltage? p. 477	**Chapter 12 Launch Lab: Penny Chemistry: 1–6, p. 433** **Connections: How Green Is White Paper? 1–3, Section 12.3, p. 465** Chapter 13 Launch Lab: What Determines Voltage? 1–5, p. 477 Unit 6 Review: 45–48, pp. 526–529
30–B2.3sts illustrate how science and technology are influenced and supported by society and have influenced and been influenced by historical development and societal needs by ■ *assessing the economic importance of electrochemical cells, particularly fuel cells, to modern society, predicting their future importance in transportation, the recycling of metals and in reducing emissions from smokestacks.*	**Connections: How Green Is White Paper? Section 12.3, p. 465**	**Connections: How Green Is White Paper? 1–3, Section 12.3, p. 465** Unit 6 Review: 45–48, pp. 526–529

	Student Textbook	Assessment Options
Skill Outcomes (Focus on problem solving)		
Initiating and Planning		
30–B2.1s ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by ■ designing an experiment, including a labelled diagram, to test predictions regarding spontaneity, products and the standard cell potential for reactions occurring in electrochemical cells ■ describing procedures for safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information ■ *developing a plan to build a battery, seeking feedback, testing and reviewing the plan, and making revisions to the plan.*	Investigation 13.C: Electroplating, Section 13.4, pp. 517–518	Investigation 13.C: Electroplating: 1–8, Section 13.4, pp. 517–518 Unit 6 Review: 22, 44, pp. 526–529
Performing and Recording		
30–B2.2s conduct investigations into relationships between and among observable variables and use a broad range of tools and techniques to gather and record data and information by ■ constructing and observing electrochemical cells ■ *investigating the issue of the disposal of used batteries and proposing alternative solutions to this problem* ■ *compiling and displaying evidence and information about voltaic and electrochemical cells, by hand or using technology, in a variety of formats, including diagrams, flow charts, tables, graphs and scatterplots.*	Chapter 13 Launch Lab: What Determines Voltage? p. 477 Investigation 13.A: Measuring Cell Potentials of Voltaic Cells, Section 13.1, pp. 488–489	Chapter 13 Launch Lab: What Determines Voltage? 1–5, p. 477 Investigation 13.A: Measuring Cell Potentials of Voltaic Cells: 1–13, Section 13.1, pp. 488–489 Unit 6 Review: 22, 44, pp. 526–529
Analyzing and Interpreting		
30–B2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions by ■ identifying the products of electrochemical cells ■ comparing predictions with observations of electrochemical cells ■ identifying the limitations of data collected on a electrochemical cell ■ explaining the discrepancies between theoretical and the actual cell potential ■ *assessing the efficiencies and practicalities of various electrochemical configurations as batteries* ■ *evaluating experimental designs for voltaic and electrolytic cells and suggesting improvements and alternatives*	Chapter 13 Launch Lab: What Determines Voltage? p. 477 Thought Lab 13.1: Assigning Reference Values, Section 13.1, p. 487 Investigation 13.A: Measuring Cell Potentials of Voltaic Cells, Section 13.1, pp. 488–489 Investigation 13.B: Electrolysis of Aqueous Potassium Iodide, Section 13.3, pp. 508–509	Chapter 13 Launch Lab: What Determines Voltage? 1–5, p. 477 Thought Lab 13.1: Assigning Reference Values: 1–5, Section 13.1, p. 487 Investigation 13.A: Measuring Cell Potentials of Voltaic Cells: 1–13, Section 13.1, pp. 488–489 Investigation 13.B: Electrolysis of Aqueous Potassium Iodide: 1–9, Section 13.3, pp. 508–509 Unit 6 Review: 10, 39, 40–43, pp. 526–529

	Student Textbook	Assessment Options
Communication and Teamwork		
30–B2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results by ■ using appropriate SI notation, fundamental and derived units to communicate answers to problems related to functioning electrolytic cells. ■ creating multiple–linked documents, selecting and integrating information from various print and electronic sources or from several parts of the same source, to prepare a presentation on the use of hydrogen fuel cells for transportation and heating.	Investigation 13.B: Electrolysis of Aqueous Potassium Iodide, Section 13.3, pp. 508–509	Investigation 13.B: Electrolysis of Aqueous Potassium Iodide: 1–9, Section 13.3, pp. 508–509

CHAPTER 13 CELLS AND BATTERIES

Curriculum Correlation

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

	Student Textbook	Assessment Options
Outcomes for Knowledge		
30–B1.1k define oxidation and reduction operationally and theoretically	Oxidation, Section 12.1, pp. 434–435 Reduction, Section 12.1, p. 435 Redox Reactions, Section 12.1, pp. 436–437	Questions for Comprehension: 1–4, Section 12.1, p. 437 Section 12.1 Review: 1, 2, p. 440 Chapter 12 Review: 4, p. 474 Chapter 12 Test Unit 6 Review: 1, 4, 6, 33, pp. 526–529
30–B1.2k define the following terms: oxidizing agent, reducing agent, oxidation number, half–reaction, disproportionation	Reducing Iron Ore, Section 12.2, pp. 452–454 Sample Problem: Assigning Oxidation Numbers, Section 12.3, pp. 457–458 Balancing Equations Using the Oxidation Number Method, Section 12.3, p. 462	Questions for Comprehension: 1–4, Section 12.1, p. 437 Section 12.1 Review: 1, 2, p. 440 Chapter 12 Test Unit 6 Review: 1, 4, 6, 33, pp. 526–529
30–B1.3k differentiate between oxidation–reduction (redox) reactions and other reactions using half–reactions and oxidation numbers	Balancing Equations Using Half–Reactions, Section 12.1, pp. 443–445 Balancing a Redox Equation in Basic Solution, Section 12.3, p. 463	Questions for Comprehension: 9–11, Section 12.2, p. 442 Chapter 12 Test Unit 6 Review: 1, 4–7, 11, 26, 29, 33–36, 44, | pp. 526–529
30–B1.4k identify electron transfer, oxidizing agents and reducing agents in redox reactions that occur in everyday life in both living and non–living systems, e.g., corrosion, *cellular respiration, photosynthesis*	Redox Reactions, Section 12.1, p. 436 Balancing Equations Using Half–Reactions, Section 12.2, p. 443 Redox Reactions Involving Molecular Compounds, Section 12.2, pp. 454–456 Sample Problem: Assigning Oxidation Numbers, Section 12.3, p. 457 Quantitative Analysis of Redox Reactions, Section 12.4, p. 467–469 **Fuel Cell History, Section 13.2, pp. 493–497** **Corrosion Prevention, Section 13.2, pp. 499–502**	Questions for Comprehension: 3, Section 12.1, p. 437 Section 12.1 Review: 7, p. 440 Practice Problems: 1, 2, Section 12.2, p. 448 Practice Problems: 12, 13, Section 12.3, p. 461 Section 12.3 Review: 6, p. 466 Chapter 12 Review: 1, 2, 5, 10, 21, pp. 474–475 Chapter 12 Test **Questions for Comprehension: 4, 6, Section 13.1, p. 482** **Section 13.2 Review: 1, p. 501** **Chapter 13 Review: 7, 8, 16, pp. 522–523** Unit 6 Review: 2, 27, 36, 37, 44, 46, pp. 526–529
30–B1.5k compare the relative strengths of oxidizing and reducing agents from empirical data	Investigation 12.A: Testing Relative Oxidizing and Reducing Strengths of Metal Atoms and Ions, Section 12.1 p. 438 Predicting the Spontaneity of Redox Reactions, Section 12.1, pp. 439–440	Investigation 12.A: Testing Relative Oxidizing and Reducing Strengths of Metal Atoms and Ions: 1–4, Section 12.1 p. 438 Questions for Comprehension: 5–8, Section 12.1, p. 440 Chapter 12 Test

	Student Textbook	Assessment Options
30–B1.6k predict the spontaneity of a redox reaction based on standard reduction potentials, and compare predictions to experimental results	Spontaneity of Redox Reactions, Section 12.1, p. 437 Predicting the Spontaneity of Redox Reactions, Section 12.1, p. 439	Questions for Comprehension: 5–8, Section 12.1, p. 440 Section 12.1 Review: 5, 6, p. 440 Chapter 12 Test **Chapter 13.3 Review: 3, p. 513** **Chapter 13 Review: 11, pp. 522–523** Unit 6 Review: 3, 25, 38, pp. 526–529
30–B1.7k write and balance equations for redox reactions in acidic, basic and neutral solutions, including disproportionation reactions, by ■ using half–reaction equations obtained from a standard reduction potential table	Writing Balanced Half–Reactions, Section 12.2, pp. 441–442 Balancing Equations Using Half–Reactions, Section 12.2, pp. 442–443 Balancing Equations for Reactions That Occur in Acidic or Basic Solutions, Section 12.2, pp. 444–445 Sample Problem: Balancing an Equation for a Reaction That Occurs in an Acidic Solution, Section 12.2, p. 446 Sample Problem: Balancing an Equation for a Reaction That Occurs in an Basic Solution, Section 12.2, pp. 447–448 Disproportionation Reactions, Section 12.2, p. 450 Sample Problem: Balancing a Disproportionation Reaction, Section 12.2, p. 451	Section 12.1 Review: 5, p. 440 Questions for Comprehension: 9–11, Section 12.2, p. 442 Practice Problems: 1, 2, Section 12.2, p. 448 Practice Problems: 3–6, Section 12.2, p. 452 Section 12.2 Review: 1–5, p. 454 Section 12.3: 6, p. 466 Practice Problems: 11–14, Section 12.3, p. 461 Practice Problems: 22, Section 12.3, p. 469 Chapter 12 Review: 1, 9, 10, 14–22, pp. 474–475 Chapter 12 Test **Section 13.2 Review: 16, p. 501** **Questions for Comprehension: 17, Section 13.3, p. 510** **Section 13.4 Review: 6, p. 520** **Chapter 13 Review: 6, p. 522** Unit 6 Review: 1, 8, 30, 34, 35, 37, 39, 46, p. 526–529
■ equations from information provided about redox changes **Note:** Students are expected to add water molecules, hydrogen ions and hydroxide ions to skeleton equations, as appropriate.	Writing Balanced Half–Reactions, Section 12.2, pp. 441–442 Balancing Equations Using Half–Reactions, Section 12.2, pp. 442–443 Balancing Equations for Reactions That Occur in Acidic or Basic Solutions, Section 12.2, pp. 444–445 Sample Problem: Balancing an Equation for a Reaction That Occurs in an Acidic Solution, Section 12.2, p. 446 Sample Problem: Balancing an Equation for a Reaction That Occurs in an Basic Solution, Section 12.2, pp. 447–448	Questions for Comprehension: 9–11, Section 12.2, p. 442 Practice Problems: 1, 2, Section 12.2, p. 448 Section 12.2 Review: 1–5, p. 454 Chapter 12 Review: 1, 14, pp. 474–475 Chapter 12 Test **Questions for Comprehension: 5, 6, Section 13.1, p. 482** **Practice Problems: 1–4, Section 13.1, p. 487** **Questions for Comprehension: 13, Section 13.2, p. 500** **Section 13.2 Review: 3, 8, 16, p. 501** **Practice Problems: 5, Section 13.3, p. 508** **Questions for Comprehension: 17, 18, Section 13.3, p. 510** **Section 13.3 Review: 4, p. 513** **Chapter 13 Review: 3, 6, 11, 13, 29, pp. 522–523** Unit 6 Review: 7, 11, 34, 36, 44, p. 526–529

	Student Textbook	Assessment Options
30–B1.7k (continued) ■ assigning oxidation numbers, where appropriate, to the species undergoing chemical change	Assigning Oxidation Numbers, Section 12.3, pp. 455–456 Sample Problem: Assigning Oxidation Numbers, Section 12.3, p. 457 Applying Oxidation Numbers to Redox Reactions, Section 12.3, pp. 459–460	Practice Problems: 7–10, Section 12.3, p. 457 Practice Problems: 15–18, Section 12.3, p. 464 Section 12.3: 5–10, p. 466 Chapter 12 Review: 3, 6, 7, 15, 20, pp. 474–475 Chapter 12 Test Unit 6 Review: 5–7, 35, pp. 526–529
30–B1.8k perform calculations to determine quantities of substances involved in redox titrations.	Stoichiometry and Redox Titrations, Section 12.4, pp. 467–468 Sample Problem: Redox Titrations, Section 12.4, pp. 468–469 Investigation 12.C: Measuring the Concentration of Vitamin C in Orange Juice, Section 12.4, pp. 470–471	Practice Problems: 19–22, Section 12.4, p. 469 Investigation 12.C: Measuring the Concentration of Vitamin C in Orange Juice: 1–8, Section 12.4, pp. 470–471 Section 12.4 Review: 1–5, p. 472 Chapter 12 Test Unit 6 Review: 39, 40, pp. 526–529
Outcomes for Science, Technology and Society (Emphasis on science and technology)		
30–B1.1sts explain how the goal of technology is to provide solutions to practical problems by ■ *describing how the process of trial and error was used by early peoples to extract metals from their ores*	Chapter 12 Launch Lab: Penny Chemistry, p. 433 Investigation 12.A: Testing Relative Oxidizing and Reducing Strengths of Metal Atoms and Ions, Section 12.1, p. 438 Connections: How Green Is White Paper? Section 12.3, p. 465	Chapter 12 Launch Lab: Penny Chemistry: 1–6, p. 433 Investigation 12.A: Testing Relative Oxidizing and Reducing Strengths of Metal Atoms and Ions: 4, Section 12.1, p. 438 Connections: How Green Is White Paper? 1–3, Section 12.3, p. 465 Unit 6 Review: 45–48, pp. 526–529
30–B1.2sts explain that technological problems often lend themselves to multiple solutions that involve different designs, materials and processes and have intended and unintended consequences by ■ *analyzing redox reactions used in industry and commerce, e.g., pulp and paper, textiles, water treatment, food processing.*	Investigation 12.B: Redox Reactions and Balanced Equations, Section 12.2, pp. 448–450 Connections: How Green Is White Paper? Section 12.3, p. 465	Investigation 12.B: Redox Reactions and Balanced Equations: 1–19, Section 12.2, pp. 448–450 Connections: How Green Is White Paper? 1–3, Section 12.3, p. 465 Unit 6 Review: 45–48, pp. 526–529
Skill Outcomes (Focus on problem solving)		
Initiating and Planning		
30–B1.1s ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by ■ designing an experiment to determine the reactivity of various metals ■ describing procedures for safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information	Investigation 12.B: Redox Reactions and Balanced Equations, Section 12.2, pp. 448–450	Investigation 12.B: Redox Reactions and Balanced Equations, Section 12.2: 1–19, pp. 448–450

	Student Textbook	Assessment Options
Performing and Recording		
30–B1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by ■ selecting and correctly using the appropriate equipment to perform a redox titration experiment ■ using a standard reduction potential table as a tool in predicting the spontaneity of redox reactions and their products ■ *creating charts, tables or spreadsheets which present the results of redox experiments.*	Investigation 12.C: Measuring the Concentration of Vitamin C in Orange Juice, Section 12.4, pp. 470–471 Investigation 12.A: Testing Relative Oxidizing and Reducing Strengths of Metal Atoms and Ions, Section 12.1, p. 438	Investigation 12.C: Measuring the Concentration of Vitamin C in Orange Juice: 1–8, Section 12.4, pp. 470–471 Investigation 12.A: Testing Relative Oxidizing and Reducing Strengths of Metal Atoms and Ions: 1–4, Section 12.1, p. 438 Investigation 12.A: Testing Relative Oxidizing and Reducing Strengths of Metal Atoms and Ions: 3, Section 12.1, p. 438
Analyzing and Interpreting		
30–B1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions by ■ evaluating data from an experiment to derive a simple reduction table ■ *interpreting patterns and trends in data derived from redox reactions* ■ *identifying the limitations of data collected.*	Investigation 12.A: Testing Relative Oxidizing and Reducing Strengths of Metal Atoms and Ions, Section 12.1, p. 438 Investigation 12.B: Redox Reactions and Balanced Equations, Section 12.2, pp. 448–450 Thought Lab 12.1: Oxidation Numbers and Lewis Structures, Section 12.3, pp. 458–459	Investigation 12.A: Testing Relative Oxidizing and Reducing Strengths of Metal Atoms and Ions: 3, Section 12.1, p. 438 Investigation 12.B: Redox Reactions and Balanced Equations: 1–19, Section 12.2, pp. 448–450 Thought Lab 12.1: Oxidation Numbers and Lewis Structures, Section 12.3, pp. 458–459
Communication and Teamwork		
30–B1.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results by ■ selecting and using appropriate numeric, symbolic, graphic and linguistic modes of representation to communicate equations for redox reactions and answers to problems related to redox titrations	Investigation 12.B: Redox Reactions and Balanced Equations, Section 12.2, pp. 448–450 Thought Lab 12.1: Oxidation Numbers and Lewis Structures, Section 12.3, pp. 458–459 Investigation 12.C: Measuring the Concentration of Vitamin C in Orange Juice, Section 12.4, pp. 470–471	Investigation 12.B: Redox Reactions and Balanced Equations, Section 12.2: 1–19, pp. 448–450 Thought Lab 12.1: Oxidation Numbers and Lewis Structures, Section 12.3, pp. 458–459 Investigation 12.C: Measuring the Concentration of Vitamin C in Orange Juice: 1–8, Section 12.4, pp. 470–471

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

	Student Textbook	Assessment Options
Outcomes for Knowledge		
30–B2.1k define anode, cathode, anion, cation, salt bridge/porous cup, electrolyte, external circuit, power supply, voltaic cell and electrolytic cell	**The Voltaic Cell, Section 13.1, p. 478** **Electrolytic Cells, Section 13.3, p. 502**	**Questions for Comprehension: 2, 3, Section 13.1, p. 480** **Questions for Comprehension: 9, Section 13.2, p. 493** **Chapter 13 Review: 1, pp. 522–523** **Chapter 13 Test**

	Student Textbook	Assessment Options
30–B2.2k identify the similarities and differences between the operation of a voltaic cell and that of an electrolytic cell	**The Voltaic Cell, Section 13.1, p. 478** **Electrolytic Cells, Section 13.3, p. 502**	**Questions for Comprehension: 2, 3, Section 13.1, p. 480** **Questions for Comprehension: 8, 9, Section 13.2, p. 493** **Section 13.2 Review: 9, p. 501** **Chapter 13 Review: 1, 13, pp. 522–523** **Chapter 13 Test** Unit 6 Review: 13, 23, 24, 28, 32, pp. 526–529
30–B2.3k predict and write the half–reaction equation that occurs at each electrode in an electrochemical cell	**Electrolytic Cells, Section 13.3, p. 502**	**Practice Problems: 5–8, Section 13.3, p. 508** **Questions for Comprehension: 17–20, Section 13.3, p. 510** **Chapter 13 Review: 13, 19, 20, pp. 522–523** **Chapter 13 Test** Unit 6 Review: 11, 31, 36, 44, pp. 526–529
30–B2.4k recognize that predicted reactions do not always occur, e.g., the production of chlorine gas from the electrolysis of brine	**Predicting the Products of Electrolysis of Aqueous Solutions, Section 13.3, p. 507** **Sample Problem: Electrolysis of an Aqueous Solution, Section 13.3, p. 507**	**Practice Problems 5–8, Section 13.3, p. 508** **Questions for Comprehension: 17, 18, Section 13.3, p. 510** **Chapter 13 Review: 5, 14, p. 513** **Chapter 13 Test** Unit 6 Review: 9, 17, 20, pp. 526–529
30–B2.5k explain that the values of standard reduction potential are all relative to zero volts set for the hydrogen electrode at standard conditions	**Cell Potentials, Section 13.1, pp. 482–483**	**Thought Lab 13.1: Assigning Reference Values: 1–5, Section 13.1, p. 487** **Section 13.1 Review: 5–7, p. 490** **Questions for Comprehension: 13–16, Section 13.2, p. 500** **Chapter 13 Review: 15, pp. 522–523** **Chapter 13 Test** Unit 6 Review: 9, 13, 23, 25, 31, pp. 526–529
30–B2.6k calculate the standard cell potential for electrochemical cells	**Calculating Standard Cell Potentials, Section 13.1, pp. 485–486** **Thought Lab 13.1: Assigning Reference Values: 1–5, Section 13.1, p. 487** **Sample Problem: Calculating a Standard Cell Potential, Given a Net Ionic Equations, Section 13.1, p. 486** **Sample Problem: Calculating a Standard Cell Potential, Given a Chemical Reaction, Section 13.1, pp. 486–487**	**Thought Lab 13.1: Assigning Reference Values: 1–5, Section 13.1, p. 487** **Practice Problems: 1–4, Section 13.1, p. 487** **Section 13.1 Review: 3–7, p. 490** **Questions for Comprehension: 13, Section 13.2, p. 500** **Chapter 13 Review: 6, 11, 12, 18, 21, pp. 522–523** **Chapter 13 Test** Unit 6 Review: 23, 28, 36, 38, pp. 526–529

	Student Textbook	Assessment Options
30–B2.7k predict the spontaneity or non–spontaneity of redox reactions based on standard cell potential and the relative positions of half–reaction equations on a standard reduction potential table	**Predicting the Products of Electrolysis of Aqueous Solutions, Section 13.3, p. 507** **Sample Problem: Electrolysis of an Aqueous Solution, Section 13.3, p. 507**	Questions for Comprehension: 5–8, Section 12.1, p. 440 Section 12.1 Review; 3, 5, 6, p. 440 **Practice Problems: 5-8, Section 13.3, p. 508** **Section 13.3 Review: 3, p. 513** **Chapter 13 Review: 11, pp. 522–523** **Chapter 13 Test** Unit 6 Review: 3, 38, pp. 526–529
30–B2.8k calculate mass, amounts, current and time in single voltaic and electrolytic cells by applying Faraday's law and stoichiometry.	**Stoichiometry and Faraday's Law, Section 13.4, p. 514** **Sample Problem: Calculating the Mass of an Electrolysis Product, Section 13.4, pp. 515–516** **Faraday's law, Section 13.4, pp. 516–517**	**Practice Problems: 9–12, Section 13.4, p. 516** **Section 13.4 Review: 1–6, p. 520** **Chapter 13 Review: 16, 21–26, pp. 522–523** **Chapter 13 Test** Unit 6 Review: 41–43,, pp. 526–529
Outcomes for Science, Technology and Society (Emphasis on science and technology)		
30–B2.1sts describe the ways in which scientific knowledge may lead to the development of new technologies and new technologies may lead to scientific discoveries by ■ *analyzing the relationship of scientific knowledge and technological development in the applications of voltaic and electrolytic cells for, e.g., batteries, electroplating, refining metals from ores, electrowinning, sanitizing swimming pools with chlorine compounds*	Connections: How Green Is White Paper? Section 12.3, p. 465 **Chapter 13 Launch Lab: What Determines Voltage? p. 477**	Connections: How Green Is White Paper? 1–3, Section 12.3, p. 465 **Chapter 13 Launch Lab: What Determines Voltage? 1–5, p. 477** Unit 6 Review: 45–48, pp. 526–529
30–B2.2sts describe applications of science and technology that have developed in response to human and environmental needs by ■ *investigating the use of technology to solve practical problems related to corrosion; e.g., galvanizing, metallurgy, magnesium coupling, painting*	Chapter 12 Launch Lab: Penny Chemistry, p. 433 Connections: How Green Is White Paper? Section 12.3, p. 465 **Chapter 13 Launch Lab: What Determines Voltage? p. 477**	Chapter 12 Launch Lab: Penny Chemistry: 1–6, p. 433 Connections: How Green Is White Paper? 1–3, Section 12.3, p. 465 **Chapter 13 Launch Lab: What Determines Voltage? 1–5, p. 477** Unit 6 Review: 45–48, pp. 526–529
30–B2.3sts illustrate how science and technology are influenced and supported by society and have influenced and been influenced by historical development and societal needs by ■ *assessing the economic importance of electrochemical cells, particularly fuel cells, to modern society, predicting their future importance in transportation, the recycling of metals and in reducing emissions from smokestacks.*	Connections: How Green Is White Paper? Section 12.3, p. 465	Connections: How Green Is White Paper? 1–3, Section 12.3, p. 465 Unit 6 Review: 45–48, pp. 526–529

	Student Textbook	Assessment Options
Skill Outcomes (Focus on problem solving)		
Initiating and Planning		
30–B2.1s ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by ■ designing an experiment, including a labelled diagram, to test predictions regarding spontaneity, products and the standard cell potential for reactions occurring in electrochemical cells ■ describing procedures for safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information ■ *developing a plan to build a battery, seeking feedback, testing and reviewing the plan, and making revisions to the plan.*	**Investigation 13.C: Electroplating, Section 13.4, pp. 517–518**	**Investigation 13.C: Electroplating: 1–8, Section 13.4, pp. 517–518** Unit 6 Review: 22, 44, pp. 526–529
Performing and Recording		
30–B2.2s conduct investigations into relationships between and among observable variables and use a broad range of tools and techniques to gather and record data and information by ■ constructing and observing electrochemical cells ■ *investigating the issue of the disposal of used batteries and proposing alternative solutions to this problem* ■ *compiling and displaying evidence and information about voltaic and electrochemical cells, by hand or using technology, in a variety of formats, including diagrams, flow charts, tables, graphs and scatterplots.*	**Chapter 13 Launch Lab: What Determines Voltage? p. 477** **Investigation 13.A: Measuring Cell Potentials of Voltaic Cells, Section 13.1, pp. 488–489**	**Chapter 13 Launch Lab: What Determines Voltage? 1–5, p. 477** **Investigation 13.A: Measuring Cell Potentials of Voltaic Cells: 1–13, Section 13.1, pp. 488–489** Unit 6 Review: 22, 44, pp. 526–529
Analyzing and Interpreting		
30–B2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions by ■ identifying the products of electrochemical cells ■ comparing predictions with observations of electrochemical cells ■ identifying the limitations of data collected on a electrochemical cell ■ explaining the discrepancies between theoretical and the actual cell potential ■ *assessing the efficiencies and practicalities of various electrochemical configurations as batteries* ■ *evaluating experimental designs for voltaic and electrolytic cells and suggesting improvements and alternatives*	**Chapter 13 Launch Lab: What Determines Voltage? p. 477** **Thought Lab 13.1: Assigning Reference Values, Section 13.1, p. 487** **Investigation 13.A: Measuring Cell Potentials of Voltaic Cells, Section 13.1, pp. 488–489** **Investigation 13.B: Electrolysis of Aqueous Potassium Iodide, Section 13.3, pp. 508–509**	**Chapter 13 Launch Lab: What Determines Voltage? 1–5, p. 477** **Thought Lab 13.1: Assigning Reference Values: 1–5, Section 13.1, p. 487** **Investigation 13.A: Measuring Cell Potentials of Voltaic Cells: 1–13, Section 13.1, pp. 488–489** **Investigation 13.B: Electrolysis of Aqueous Potassium Iodide: 1–9, Section 13.3, pp. 508–509** Unit 6 Review: 10, 39, 40–43, pp. 526–529

	Student Textbook	Assessment Options
Communication and Teamwork		
30–B2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results by ■ using appropriate SI notation, fundamental and derived units to communicate answers to problems related to functioning electrolytic cells. ■ creating multiple–linked documents, selecting and integrating information from various print and electronic sources or from several parts of the same source, to prepare a presentation on the use of hydrogen fuel cells for transportation and heating.	**Investigation 13.B: Electrolysis of Aqueous Potassium Iodide, Section 13.3, pp. 508–509**	**Investigation 13.B: Electrolysis of Aqueous Potassium Iodide: 1–9, Section 13.3, pp. 508–509**

CHAPTER 14 STRUCTURE AND PHYSICAL PROPERTIES OF ORGANIC COMPOUNDS

Curriculum Correlation

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

	Student Textbook	Assessment Options
Outcomes for Knowledge		
30–C1.1k define organic compounds as compounds containing carbon, recognizing inorganic exceptions such as carbonates, cyanides and carbides	**Defining Organic Compounds, Section 14.1, pp. 538-539**	**Section 14.1 Review: 1-7, p. 543** **Chapter 14 Review: 1-4, pp. 584-585** **Chapter 14 Test** Unit 7 Review: 1-4, pp. 620-623
30–C1.2k identify and describe significant organic compounds in daily life, demonstrating generalized knowledge of their origins and applications; e.g., *methane, methanol, ethane, ethanol, ethanoic acid, propane, benzene, octane, glucose, polyethylene*	**Throughout Chapters 14** and 15	**Section 14.1 Review: 1-7, p. 543** **Section 14.4 Review: 1-8, p. 582** **Chapter 14 Review: 1-4, 23-25, pp. 584-585** **Chapter 14 Test** Unit 7 Review: 32-36, pp. 620-623
30–C1.3k name and draw structural, condensed structural, and line diagrams and formulas for saturated and unsaturated aliphatic (including cyclic) and aromatic carbon compounds [bullet] containing up to 10 carbon atoms in the parent chain/cyclical structure ■ containing only one type of a functional group (including only alcohols, carboxylic acids, esters, or multiple bond ■ using International Union of Pure and Applied Chemistry (IUPAC) nomenclature guidelines	**Modelling Alkanes, Section 14.2, p. 545** **Naming Alkanes, Section 14.2, pp. 546-548** **Sample Problem: Naming Alkanes, Section 14.2, p. 548** **Drawing Alkanes, Section 14.2, pp. 549-550** **Sample Problem: Drawing an Alkane, Section 14.2, p. 550** **Modelling Alkenes, Section 14.2, pp. 552-553** **Naming Alkenes, Section 14.2, p. 553** **Sample Problem: Naming Alkenes, Section 14.2, p. 553** **Sample Problem: Drawing Alkenes, Section 14.2, p. 555** **Naming and Drawing Alkynes, Section 14.2, p. 556** **Naming Cyclic Hydrocarbons, Section 14.2, p. 558** **Sample Problem: Naming Cyclic Hydrocarbons, Section 14.2, p. 559** **Naming Aromatic Hydrocarbons, Section 14.2, p. 561** **Sample Problem: Naming and Drawing Aromatic Hydrocarbons, Section 14.2, p. 562** **Naming and Drawing Alcohols, Section 14.3, p. 566** **Sample Problem: Naming Alcohols, Section 14.3, pp. 566-567** **Naming and Drawing Alkyl Halides, Section 14.3, p. 568** **Naming and Drawing Carboxylic Acids, Section 14.3, p. 570** **Sample Problem: Naming Carboxylic Acids, Section 14.3, p. 570** **Naming and Drawing Esters, Section 14.3, pp. 571-572**	**Practice Problems: 1-3, Section 14.2, p. 549** **Practice Problems: 4-9, Section 14.2, pp. 550-551** **Practice Problems: 10-13, Section 14.2, p. 554** **Practice Problems: 14, 15, Section 14.2, p. 555** **Practice Problems: 16, 17, Section 14.2, pp. 556-557** **Practice Problems: 18-23, Section 14.2, pp. 559-560** **Practice Problems: 24-27, Section 14.2, pp. 562** **Section 14.2 Review: 1-8, p. 564** **Practice Problems: 28-30, Section 14.3, p. 567** **Practice Problems: 31-32, Section 14.3, p. 569** **Practice Problems: 33-36, Section 14.3, p. 570**

	Student Textbook	Assessment Options
30–C1.3k (continued)	**Sample Problem: Naming Esters, Section 14.3, pp. 572**	**Practice Problems: 37, 38, Section 14.3, p. 572** **Section 14.3 Review: 1, 2, 7, p. 574** **Chapter 14 Review: 7, 9-13, 22, pp. 584-585** **Chapter 14 Test** Unit 7 Review: 5-7, 10-13, 18, 21, 22, 24, 27, pp. 620-623
30–C1.4k identify types of compounds from the functional groups (carboxyl, hydroxyl, ester linkage, and halogen), given the structural formula	**Hydrocarbon Derivatives, Section 14.3, pp. 565-566**	**Section 14.3 Review: 6, p. 574** **Chapter 14 Review: 8, 9, 12, pp. 584-585** **Chapter 14 Test** Unit 7 Review: 7, 8, 11, 27, pp. 620-623
30–C1.5k define structural isomerism as compounds having the same empirical formulas but different structural formulas and relate to variations in properties of structural isomers	**Structural Isomerism, Section 14.3, p. 573**	**Questions for Comprehension: 1, 2, Section 14.3, p. 573** **Section 14.3 Review: 3, 4, p. 574** **Chapter 14 Review: s13, 14, pp. 584-585** **Chapter 14 Test** Unit 7 Review: 9, 13, 25, pp. 620-623
30–C1.6k compare, both within a homologous series and between compounds with different functional groups, the boiling points and solubility of examples of aliphatics, aromatics, alcohols and carboxylic acids	**Physical Properties of Alkanes, Section 14.1, p. 551** **Physical Properties of Alkenes, Section 14.1, p. 555** **Physical Properties of Alkynes, Section 14.1, p. 557** **Physical Properties of Aromatic Compounds, Section 14.1, p. 561** **Physical Properties of Alcohols, Section 14.2, p. 567** **Physical Properties of Carboxylic Acids, Section 14.2, p. 571** **Physical Properties of Esters, Section 14.2, p. 573**	**Section 14.3 Review: 2, 5, 8, p. 574** **Section 14.4 Review: 3, p. 582** **Chapter 14 Review: 14-19, 21, 22, pp. 584-585** **Chapter 14 Test** Unit 7 Review: 23, 26, 32-36, pp. 620-623
30–C1.7k describe, in general terms, the physical, chemical and technological processes used to separate organic compounds from natural mixtures or solutions by fractional distillation and solvent extraction; e.g., *petroleum refining, bitumen recovery.*	**Refining and Using Organic Compounds, Section 14.4, pp. 575-582**	**Section 14.4 Review: 1-8, p. 582** **Chapter 14 Review: 15, 16, 19, 21, 23-25, pp. 584-585** **Chapter 14 Test** Unit 7 Review: 14, 23, 26, 30-36, pp. 620-623
Outcomes for Science, Technology and Society (Emphasis on social and environmental contexts)		
30–C1.1sts demonstrate an understanding that science and technology are developed to meet societal needs and expand human capability by ■ *describing where organic compounds are used in processes and common products; e.g., hydrogenation to produce margarine, esters used as flavouring agents*	**Chapter 14 Launch Lab: Familiar Organic Compounds, p. 537** **Thought Lab 14.1: Nanotubes, Buckyballs, and Allotropes, Section 14.1, p. 539** **Investigation 14.B: Modelling Organic Compounds, Section 14.2, p. 563** **Connections: Tar Sands and Bitumen, Section 14.4, pp. 576-577**	**Chapter 14 Launch Lab: Familiar Organic Compounds: 1, 2, p. 537** **Thought Lab 14.1: Nanotubes, Buckyballs, and Allotropes: 1-3, Section 14.1, p. 539** **Investigation 14.B: Modelling Organic Compounds: 5, 6, Section 14.2, p. 563** **Connections: Tar Sands and Bitumen: 1-3, Section 14.4, pp. 576-577** Unit 7 Review: 32-36, pp. 620-623
30–C1.2sts explain how science and technology are influenced and supported by society and have influenced, and been influenced by, historical development and societal needs by	**Chapter 14 Launch Lab: Familiar Organic Compounds, p. 537** **Thought Lab 14.1: Nanotubes, Buckyballs, and Allotropes, Section 14.1, p. 539**	**Chapter 14 Launch Lab: Familiar Organic Compounds: 1, 2, p. 537** **Thought Lab 14.1: Nanotubes, Buckyballs, and Allotropes: 1-3, Section 14.1, p. 539**

	Student Textbook	Assessment Options
30–C1.2sts (continued) ■ *explaining how, as a result of chemistry and chemical technology, synthetic compounds of great benefit to society have been produced, e.g., plastics, medicines, hydrocarbon fuels and pesticides.*	**Investigation 14.A: Comparing Organic and Inorganic Compounds, Section 14.1, pp. 540-541** **Connections: Tar Sands and Bitumen, Section 14.4, p. 576**	**Investigation 14.A: Comparing Organic and Inorganic Compounds: 7, Section 14.1, pp. 540-541** **Connections: Tar Sands and Bitumen: 1-3, Section 14.4, p. 576** Unit 7 Review: 32-36, pp. 620-623
Skill Outcomes (Focus on problem solving)		
Initiating and Planning		
30–C1.1s ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by ■ designing a procedure to identify types of organic compounds	**Investigation 14.C: Separate an Organic Mixture, Section 14.4, p. 581**	**Investigation 14.C: Separate an Organic Mixture: 1-5, Section 14.4, p. 581** Unit 7 Review: 14, 23, 26, 30-36, pp. 620-623
■ describing procedures for safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information		
■ designing a procedure for separating a mixture of organic compounds based on boiling point differences.		
Performing and Recording		
30–C1.2s conduct investigations into relationships between and among observable variables and use a broad range of tools and techniques to gather and record data and information by ■ building molecular models depicting the structures of selected organic and inorganic compounds	**Investigation 14.B: Modelling Organic Compounds, Section 14.2, p. 563**	**Investigation 14.B: Modelling Organic Compounds: 1-6, Section 14.2, p. 563**
■ performing an experiment to compare the properties of organic to inorganic compounds, e.g., solubility, viscosity, density, conductivity, reactivity.	**Investigation 14.A: Comparing Organic and Inorganic Compounds, Section 14.1, pp. 540-541**	**Investigation 14.A: Comparing Organic and Inorganic Compounds: 1-7, Section 14.1, pp. 540-541**
Analyzing and Interpreting		
30–C1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions by ■ following appropriate IUPAC guidelines in writing the names and formulas of organic compounds	**Investigation 14.B: Modelling Organic Compounds, Section 14.2, p. 563**	**Investigation 14.B: Modelling Organic Compounds: 1-6, Section 14.2, p. 563**
■ compiling and organizing data to compare the properties of structural isomers; e.g., *pairs of hydrocarbon isomers, primary, secondary and tertiary alcohols*	**Thought Lab 14.1: Nanotubes, Buckyballs, and Allotropes, Section 14.1, p. 539**	**Thought Lab 14.1: Nanotubes, Buckyballs, and Allotropes: 1-3, Section 14.1, p. 539**
■ interpreting the results of a test to distinguish between a saturated and an unsaturated aliphatic using aqueous bromine or potassium permanganate solutions	Chapter 15 Launch Lab: Comparing the Reactivity of Alkanes and Alkenes, p. 587	Chapter 15 Launch Lab: Comparing the Reactivity of Alkanes and Alkenes: 1-4, p. 587
■ *analyzing the contributions and limitations of scientific and technological knowledge to societal decision making in relation to the costs and benefits of society's use of petrochemicals, pharmaceuticals and pesticides.*	**Connections: Tar Sands and Bitumen, Section 14.4, p. 576**	**Connections: Tar Sands and Bitumen: 1-3, Section 14.4, p. 576**
Communication and Teamwork		
30–C1.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results by ■ *using advanced menu features within a word processor to accomplish a task and to insert tables, graphs, text and graphics.*	**Investigation 14.A: Comparing Organic and Inorganic Compounds, Section 14.1, pp. 540-541** **Connections: Tar Sands and Bitumen, Section 14.4, p. 576**	**Investigation 14.A: Comparing Organic and Inorganic Compounds: 1-7, Section 14.1, pp. 540-541** **Connections: Tar Sands and Bitumen: 1, 2, Section 14.4, p. 576**

CHAPTER 15 REACTION OF ORGANIC COMPOUNDS

Curriculum Correlation

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

	Student Textbook	Assessment Options
Outcomes for Knowledge		
30–C2.1k define, illustrate and provide examples of simple addition, substitution, elimination, esterification and combustion reactions	**Combustion Reactions, Section 15.1, p. 588** **Addition, Elimination, and Substitution Reactions, Section 15.1, p. 589** **Addition Reactions, Section 15.1, pp. 590-591** **Elimination Reactions, Section 15.1, p. 593** **Substitution Reactions, Section 15.1, pp. 593-594** **Esterification Reactions, Section 15.1, pp. 594-595** **Sample Problems: Addition, Substitution, Elimination, and Esterification Reactions, Section 15.1, p. 596**	**Questions for Comprehension: 1-6, Section 15.1, p. 589** **Practice Problems: 1-6, Section 15.1, pp. 596-597** **Section 15.1 Review: 1-6, pp. 602** **Chapter 15 Review: 1, 3, 10, pp. 616-617** **Chapter 15 Test** Unit 7 Review: 15-20, 28, 29-31, 34-36, pp. 620-623
30–C2.2k predict products and write and interpret balanced equations for the above reactions	**Combustion Reactions, Section 15.1, p. 588** **Addition, Elimination, and Substitution Reactions, Section 15.1, p. 589** **Addition Reactions, Section 15.1, pp. 590-591** **Elimination Reactions, Section 15.1, p. 593** **Substitution Reactions, Section 15.1, pp. 593-594** **Esterification Reactions, Section 15.1, pp. 594-595** **Sample Problems: Addition, Substitution, Elimination, and Esterification Reactions, Section 15.1, p. 596**	**Questions for Comprehension: 1-6, Section 15.1, p. 589** **Practice Problems: 1-6, pp. 596-597** **Section 15.1 Review: 1-6, pp. 602** **Chapter 15 Review: 1, 2, 5-7, 10, 16 -20, pp. 616-617** **Chapter 15 Test** Unit 7 Review: 15-20, pp. 620-623
30–C2.3k define, illustrate and provide examples of monomers, e.g., ethene, polymers, e.g., polyethylene, and polymerization in living systems, *e.g., carbohydrates, proteins and nonliving systems, e.g., nylon, polyester, plastics*	**Polymer Chemistry, Section 15.2, pp. 603-605** **Sample Problem: Classifying a Polymerization Reaction, Section 15.2, p. 606**	**Practice Problems: 7-12, pp. 606-607** **Section 15.2 Review: 1-5, p. 614** **Chapter 15 Review: 2, 8-17, 19, 20, 24, 28, pp. 616-617** **Chapter 15 Test** Unit 7 Review: 18-20, 29, 31, 34, 35, pp. 620-623

	Student Textbook	Assessment Options
30–C2.4k relate the reactions described above to major reactions for producing energy and economically important compounds from fossil fuels.	Organic Reactions and the Petrochemical Industry in Alberta, Section 15.2, pp. 609 Risks of the Polymer Industry, Section 15.2, pp. 610-611 Natural Polymers, Section 15.2, pp. 611-613	Questions for Comprehension: 1-6, Section 15.1, p. 589 Section 15.2 Review: 1-7, p. 614 Chapter 15 Review: 18-28, pp. 616-617 Chapter 15 Test Unit 7 Review: 32, 33, 35, 36, pp. 620-623
Outcomes for Science, Technology and Society (Emphasis on social and environmental contexts)		
30–C2.1sts develop an understanding that science and technology are developed to meet societal needs and expand human capability by ■ *describing processes for obtaining economically important compounds from fossil fuels, (e.g., compare hydro-cracking and catalytic reforming, describe bitumen upgrading)* ■ *describing major reactions of the petrochemical industry in Alberta, e.g., production of methanol, ethylene glycol, polyethylene, polyvinyl chloride (PVC), urea, formaldehyde* ■ *investigating the application of nanoscience and nanotechnology in the petrochemical industry and the medical sciences*	**Thought Lab 15.1: Fossil Fuels and Climate Change, Section 15.1, p. 589**	**Thought Lab 15.1: Fossil Fuels and Climate Change: 1-3, Section 15.1, p. 589** **Chapter 15 Review: 18-28, pp. 616-617** Unit 7 Review: 32-36, pp. 620-623

30–C2.2sts develop an understanding that science and technology are influenced and supported by society and have influenced, and been influenced by, historical development and societal needs by
■ *describing processes involved in producing gasoline, e.g.,*
  ■ *adjusting octane rating*
  ■ *reducing sulfur content*
  ■ *adding compounds such as oxygenated additives (blending with ethanol)*
	Thought Lab 15.1: Fossil Fuels and Climate Change, Section 15.1, p. 589	**Thought Lab 15.1: Fossil Fuels and Climate Change: 1-3, Section 15.1, p. 589**
		Chapter 15 Review: 18-28, pp. 616-617
		Unit 7 Review: 32-36, pp. 620-623

30–C2.3sts develop an understanding that science and technology have both intended and unintended consequences for humans and the environment by
■ *assessing the positive and negative effects of various reactions involving organic compounds, relating these processes to quality of life and potential health and environmental issues, e.g.,*
  ■ *burning fossil fuels and climate change*
  ■ *production of pharmaceuticals and foods*
  ■ *byproducts (CO_2, dioxins) of common reactions*
  ■ *recycling of plastics*
  ■ *impact of CFCs, HCFCs on the ozone layer*
  ■ *transfats in the diet*
■ *assessing the implications of the development of nanoscience and nanotechnology for application in the petrochemical industry and the medical sciences on society and the environment.*
	Thought Lab 15.1: Fossil Fuels and Climate Change, Section 15.1, p. 589
	
	Connections: Trans Fat in the Diet, Section 15.1, p. 592
	
	Thought Lab 15.2: Problem Solving with Organic Compounds, Section 15.1, pp. 599-601
		Thought Lab 15.1: Fossil Fuels and Climate Change: 1-3, Section 15.1, p. 589
		
		Connections: Trans Fat in the Diet: 1-3, Section 15.1, p. 592
		
		Thought Lab 15.2: Problem Solving with Organic Compounds: 1-3, Section 15.1, pp. 599-601
		Chapter 15 Review: 18-28, pp. 616-617
		Unit 7 Review: 32-36, pp. 620-623

	Student Textbook	Assessment Options
Skill Outcomes (Focus on problem solving)		
Initiating and Planning		
30–C2.1s ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by ■ predicting the ester formed from an alcohol and an organic acid ■ describing procedures for safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information ■ *designing a procedure to prepare a polymer.*	**Investigation 15.A: Preparing Esters, Section 15.1, pp. 597-599** **Investigation 15.B: Modelling and Making Polymers, Section 15.2, pp. 607-608**	**Investigation 15.A: Preparing Esters: 1-4, Section 15.1, pp. 597-599** Unit 7 Review: 31, pp. 620-623 **Investigation 15.B: Modelling and Making Polymers: 1-8, Section 15.2, pp. 607-608**
Performing and Recording		
30–C2.2s conduct investigations into relationships between and among observable variables and use a broad range of tools and techniques to gather and record data and information by ■ performing an experiment to investigate the reactions of organic compounds ■ *synthesizing a polymer, e.g., nylon or "slime"* ■ *producing an ester* ■ *investigating methods of making soap* ■ *using library and electronic research tools to collect information on, e.g.,* ■ bitumen upgrading ■ *determining the octane ratings of gasoline* ■ *the costs and benefits of supporting the petrochemical industry.*	**Chapter 15 Launch Lab: Comparing the Reactivity of Alkanes and Alkenes, p. 587** **Thought Lab 15.2: Problem Solving with Organic Compounds, Section 15.2, pp. 599-601** **Investigation 15.B: Modelling and Making Polymers, Section 15.2, pp. 607-608**	**Chapter 15 Launch Lab: Comparing the Reactivity of Alkanes and Alkenes: 1-4, p. 587** **Thought Lab 15.2: Problem Solving with Organic Compounds: 1-3, Section 15.2, pp. 599-601** **Investigation 15.B: Modelling and Making Polymers: 1-8, Section 15.2, pp. 607-608**
Analyzing and Interpreting		
30–C2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions by ■ using appropriate chemical symbols and nomenclature in writing organic chemical reactions	**Investigation 15.B: Modelling and Making Polymers, Section 15.2, pp. 607-608**	**Investigation 15.B: Modelling and Making Polymers: 1-8, Section 15.2, pp. 607-608**
■ investigating sources of greenhouse gases, i.e., methane, carbon dioxide, water and dinitrogen oxide (nitrous oxide) and analyze their contribution to climate change ■ using models to illustrate polymerization ■ *analyzing a process for producing polymers* ■ *analyzing efficiencies and negative byproducts related to chemical reaction processes in organic chemistry.*	**Thought Lab 15.1: Fossil Fuels and Climate Change, Section 15.1, p. 589** **Investigation 15.B: Modelling and Making Polymers, Section 15.2, pp. 607-608**	**Thought Lab 15.1: Fossil Fuels and Climate Change: 1-3, Section 15.1, p. 589** **Investigation 15.B: Modelling and Making Polymers: 1-8, Section 15.2, pp. 607-608**
Communication and Teamwork		
30–C2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results by ■ using advanced menu features within a word processor to insert tables, graphs, text and graphics when preparing a report on an issue related to society's use of organic chemistry.	**Thought Lab 15.2: Problem Solving with Organic Compounds, Section 15.2, pp. 599-601**	**Thought Lab 15.2: Problem Solving with Organic Compounds: 1-3, Section 15.2, pp. 599-601**

CHAPTER 16 CHEMICAL EQUILIBRIUM

Curriculum Correlation

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

	Student Textbook	Assessment Options
Outcomes for Knowledge		
30–D1.1k define equilibrium and state the criteria that apply to a chemical system in equilibrium, i.e., closed system, constancy of properties, equal rates of forward and reverse reactions	**Chemical Equilibrium, Section 16.1, p. 634** **Conditions That Apply to All Equilibrium Systems, Section 16.1, pp. 636–637**	**Questions for Comprehension: 1–3, Section 16.1, p. 636** **Section 16.1 Review: 1–11, p. 638** **Chapter 16 Review: 1–3, 6, 7, 22, pp. 676–677** **Chapter 16 Test** Unit 8 Review: 1–3, 5–11, 20, pp. 724–727
30–D1.2k identify, write and interpret chemical equations for systems at equilibrium	**The Law of Chemical Equilibrium, Section 16.2, pp. 639–641** **Equilibrium Law Expression, Section 16.2, p. 641** **Sample Problem: Writing Equilibrium Expression for Homogeneous Chemical Reactions, Section 16.2, p. 641** **Sample Problem: Calculating an Equilibrium Constant, Section 16.2, pp. 642–643** **Sample Problem: Calculating an Equilibrium Concentration, Section 16.2, p. 643**	**Practice Problems: 1–5, Section 16.2, p. 641** **Practice Problems: 6–10, Section 16.2, p. 644** **Section 16.2 Review: 1–8, p. 655** **Chapter 16 Review: 4, 5, 8–12, 14–19, 24, pp. 676–677** **Chapter 16 Test** Unit 8 Review: 2–4, 7–10, 12, 19, 26–31, 33, 37, 38, 41, 50, 52, 53, pp. 724–727
30–D1.3k predict, qualitatively, using Le Châtelier's principle, shifts in equilibrium caused by changes in temperature, pressure, volume, concentration or the addition of a catalyst, and describe how these changes affect the equilibrium constant	**Le Châtelier's Principle, Section 16.2, pp. 646–647** **Sample Problem: Temperature and the Extent of a Reaction, Section 16.2, p. 640** **Sample Problem: Using Le Châtelier's Principle, Section 16.2, p. 651**	**Practice Problems: 11–15, Section 16.2, pp. 649–650** **Practice Problems: 16–20, Section 16.2, pp. 651** **Section 16.2 Review: 3, 5–8, p. 655** **Chapter 16 Review: 10–14, 18, 19, 24, pp. 676–677** **Chapter 16 Test** Unit 8 Review: 9, 26–30, 34, pp. 724–727
30–D1.4k define K_c and write equilibrium law expressions for given chemical equations, using lowest whole–number coefficients	**The Law of Chemical Equilibrium, Section 16.2, pp. 639–641** **Equilibrium Law Expression, Section 16.2, p. 641** **Sample Problem: Writing Equilibrium Expression for Homogeneous Chemical Reactions, Section 16.2, p. 641** **Sample Problem: Using Stoichiometry to Calculate Kc, Section 16.3, pp. 657–658** **Sample Problem: Using the Approximation Method, Section 16.3, pp. 659–660**	**Practice Problems: 1–5, Section 16.2, p. 641** **Practice Problems: 6–10, Section 16.2, p. 644** **Section 16.2 Review: 1–8, p. 655** **Practice Problems: 21–24, Section 16.3, p. 658** **Practice Problems: 25–29, Section 16.3, p. 660** **Section 16.3 Review: 1–5, p. 665** **Chapter 16 Review: 3, 5–7, pp. 676–677** **Chapter 16 Test** Unit 8 Review: 4, 7, 10, 11, 26–30, pp. 724–727

	Student Textbook	Assessment Options
30–D1.5k describe Brönsted–Lowry acids as proton donors and bases as proton acceptors	Understanding Acids and Bases, Section 17.2, p. 684 Sample Problem: Conjugate Acid–Base Pairs, Section 17.2, pp. 686–687	Questions for Comprehension: 3–5, Section 17.2, p. 686 Practice Problems: 1–4, Section 17.2, p. 687 Section 17.3 Review: 1–6, p. 704 Chapter 17 Test Unit 8 Review: 16–19, 21–23, 25, 31–39, 44–47, 50, 52, 53, pp. 724–727
30–D1.6k write Brönsted–Lowry equations and predict whether reactants or products are favoured for acid–base equilibrium reactions (including indicators, polyprotic acids, and polyprotic bases)	Predicting the Direction of Reaction for an Acid–Base Reaction, Section 17.2, p. 689 Sample Problem: Predicting the Direction of an Acid–Base Reaction, Section 17.2, p. 689	Practice Problems: 8–10, Section 17.2, p. 690 Section 17.2 Review: 1–4, p. 690 Practice Problems: 11–13, Section 17.3, p. 692 Chapter 17 Review: 7, p. 720–721 Chapter 17 Test Unit 8 Review: 16–19, 21–23, 25, 31–39, 44–47, 50, 52, 53, pp. 724–727
30–D1.7k identify polyprotic acids, polyprotic bases, conjugate pairs and amphiprotic substances	Both an Acid and a Base: Amphiprotic Substances, Section 17.2, p. 688 Sample Problem: An Amphiprotic Ion, Section 17.2, p. 688	Practice Problems: 5–7, Section 17.2, p. 688 Section 17.2 Review: 3, p. 690 Chapter 17 Test Unit 8 Review: 16–19, 23, 25, 31, 34, pp. 726–729
30–D1.8k define a buffer as relatively large amounts of a weak acid and its conjugate base in equilibrium that maintain a relatively constant pH when small amounts of acid or base are added	Buffer Solutions, Section 17.4, pp. 712–713	Questions for Comprehension: 1, 2, Section 17.1, p. 682 Section 17.4 Review: 6–8, p. 718 Chapter 17 Review: 11, 26, pp. 720–721 Chapter 17 Test Unit 8 Review: 24, 25, 43, 47, pp. 724–727
30–D1.9k sketch and qualitatively interpret titration curves of monoprotic and polyprotic acids and bases identifying equivalence points and regions of buffering for weak acid–strong base, strong acid–weak base, and strong acid–strong base.	**Thought Lab 16.1: Finding and Equilibrium Law, Section 16.3, p. 661** Titration Curves and Buffers, Section 17.4, pp. 705–708	**Thought Lab 16.1: Finding and Equilibrium Law: 1–7, Section 16.3, p. 661** Questions for Comprehension: 9–12, Section 17.4, p. 710 Section 17.4 Review: 1–8, p. 718 Chapter 17 Review: 25, pp. 720–721 Chapter 17 Test Unit 8 Review: 39, 44–47, pp. 724–727
Outcomes for Science, Technology and Society (Emphasis on nature of science)		
30–D1.1sts demonstrate an understanding that the goal of science is knowledge about the natural world by ■ *applying equilibrium theories and principles to analyze a variety of phenomena, e.g.,* – *carbon dioxide escaping from an open bottle/can of carbonated beverage* – *role of the oceans in the carbon cycle* – *solubility of oxygen gas in lake water* – *acid precipitation (deposition)* – *blood gases in deep–sea diving* – *buffers in living systems*	**Chapter 16 Launch Lab: The Chemical Blues, p. 633** **Connections: The Development of Equilibrium Theories, Section 16.2, p. 645**	**Chapter 16 Launch Lab: The Chemical Blues: 1, 2, p. 633** **Connections: The Development of Equilibrium Theories, Section 16.2, p. 645** Chapter 17 Review: 2, 21, 22, 27–29, pp. 720–721 Unit 8 Review: 13–15, 39–53, pp. 724–727

	Student Textbook	Assessment Options
30–D1.2sts demonstrate an understanding that scientific knowledge and theories develop through hypotheses, the collection of evidence through experimentation and the ability to provide explanations, e.g., *research how equilibrium theories and principles developed*	**Chapter 16 Launch Lab: The Chemical Blues, p. 633** **Connections: The Development of Equilibrium Theories, Section 16.2, p. 645**	**Chapter 16 Launch Lab: The Chemical Blues: 1, 2, p. 633** **Connections: The Development of Equilibrium Theories: 1–3, Section 16.2, p. 645** Chapter 17 Review: 2, 21, 22, pp. 720–721 Unit 8 Review: 13–15, 39–53, pp. 724–727
30–D1.3sts demonstrate an understanding that the goal of technology is to provide solutions to practical problems by ■ *analyzing how equilibrium principles have been applied in industrial processes, e.g.,* *– the Haber–Bosch process for making ammonia* *– the Solvay process for making sodium carbonate* – production of methanol.	**Chapter 16 Launch Lab: The Chemical Blues, p. 633** **Connections: The Development of Equilibrium Theories, Section 16.2, p. 645** **Investigation 16.B: Disturbing Equilibrium, Section 16.2, pp. 652–654**	**Chapter 16 Launch Lab: The Chemical Blues: 1, 2, p. 633** **Connections: The Development of Equilibrium Theories: 1–3, Section 16.2, p. 645** **Investigation 16.B: Disturbing Equilibrium: 1–8, Section 16.2, pp. 652–654** **Section 16.4 Review: 1–4, p. 674** Section 17.1 Review: 1–6, p. 683 Unit 8 Review: 13–15, 39–53, pp. 724–727
Skill Outcomes (Focus on scientific inquiry)		
Initiating and Planning		
30–D1.1s ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by ■ predicting variables that can cause a shift in equilibrium ■ designing an experiment to show equilibrium shifts, e.g., *colour change, temperature change, precipitation* ■ describing procedures for safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information ■ *designing a buffering system.*	**Chapter 16 Launch Lab: The Chemical Blues, p. 633** **Investigation 16.A: Modelling Equilibrium, Section 16.1, pp. 635–636** **Investigation 16.B: Disturbing Equilibrium, Section 16.2, pp. 652–654** **Investigation 16.C: Using Experimental Data to Determine an Equilibrium Constant, Section 16.3, pp. 662–665**	**Chapter 16 Launch Lab: The Chemical Blues: 1, 2, p. 633** **Investigation 16.A: Modelling Equilibrium: 1–10, Section 16.1, pp. 635–636** **Investigation 16.B: Disturbing Equilibrium: 1–8, Section 16.2, pp. 652–654** **Investigation 16.C: Using Experimental Data to Determine an Equilibrium Constant: 1–4, Section 16.3, pp. 662–665** Unit 8 Review: 39, 40, 44, 47, pp. 724–727
Performing and Recording		
30–D1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by ■ performing an experiment to test, qualitatively, predictions of equilibrium shifts, e.g., *colour change, temperature change, precipitation, and gas production* ■ *preparing a buffer to investigate the relative abilities of a buffer and a control; i.e., water, to resist a pH change when a small amount of strong acid or strong base is added.*	**Investigation 16.A: Modelling Equilibrium, Section 16.1, pp. 635–636** **Investigation 16.B: Disturbing Equilibrium, Section 16.2, pp. 652–654** **Investigation 16.C: Using Experimental Data to Determine an Equilibrium Constant, Section 16.3, pp. 662–665**	**Investigation 16.A: Modelling Equilibrium: 1–10, Section 16.1, pp. 635–636** **Investigation 16.B: Disturbing Equilibrium: 1–8, Section 16.2, pp. 652–654** **Investigation 16.C: Using Experimental Data to Determine an Equilibrium Constant: 1–4, Section 16.3, pp. 662–665** Unit 8 Review: 39, 40, 44, 47, pp. 724–727
Analyzing and Interpreting		
30–D1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions by ■ writing the equilibrium law expression for a given equation ■ analyzing, qualitatively, the changes in concentrations of reactants and products after an equilibrium shift ■ interpreting data from a graph to determine when equilibrium is established, and determining the cause of a stress on the system.	**Investigation 16.B: Disturbing Equilibrium, Section 16.2, pp. 652–654** **Thought Lab 16.1: Finding an Equilibrium Law, Section 16.3, p. 661** **Investigation 16.C: Using Experimental Data to Determine an Equilibrium Constant, Section 16.3, pp. 662–665**	**Investigation 16.B: Disturbing Equilibrium: 1–8, Section 16.2, pp. 652–654** **Thought Lab 16.1: Finding an Equilibrium Law, Section 16.3, p. 661** **Investigation 16.C: Using Experimental Data to Determine an Equilibrium Constant: 1–4, Section 16.3, pp. 662–665** Unit 8 Review: 10, 26–30, 32–34, 39, 47, 49–53, pp. 724–727

	Student Textbook	Assessment Options
Communication and Teamwork		
30–D1.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results by ■ *working collaboratively with team members to develop an illustration and explanation of reversible reactions* ■ *using advanced menu features within a word processor to develop a group report on equilibrium systems.*	**Investigation 16.B: Disturbing Equilibrium, Section 16.2, pp. 652–654**	**Investigation 16.B: Disturbing Equilibrium: 1–8, Section 16.2, pp. 652–654**

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

	Student Textbook	Assessment Options
Outcomes for Knowledge		
30–D2.1k recall the concepts pH and hydronium ion concentration, pOH and hydroxide ion concentration in relation to acids and bases	Describing Acidic and Basic Solutions, Unit 8 Preparation, pp. 630–631	**Chapter 16 Review: 23, pp. 676–677** Chapter 17 Review: 1, 3–6, 8, 13, 15, 19, pp. 720–721 Chapter 17 Test Unit 8 Review: 31, 32, 34, 36, 39, 43, 47, 49, 50, pp. 724–727
30–D2.2k define K_w , K_a , K_b and use these to determine pH, pOH, $[H_3O^+]$, $[OH^-]$ of acidic and basic solutions	Acid–Base Equilibriums, Section 17.3, p. 691 Sample Problem: Acid Ionization Expressions, Section 17.3, p. 691 Sample Problem: Determining K_a and Percent Ionization, Section 17.3, pp. 692–693 The Ion Product Constant for Water, Section 17.3, pp. 695–696 The Base Ionization Constant K_b, Section 17.3, pp. 696–697 Sample Problem: Calculating K_b for a Weak Base, Section 17.3, p. 697 Calculating the pH of a Solution of a Weak Acid or a Weak Base, Section 17.3, p. 698 Sample Problem: Calculating the pH of a Weak Acid, Section 17.3, p. 699 Sample Problem: Calculating the pH of a Weak Base, Section 17.3, p. 700	Practice Problems: 11–13, Section 17.3, p. 692 Practice Problems: 14–18, Section 17.3, p. 693 Questions for Comprehension: 6–8, Section 17.3, p. 696 Practice Problems: 19–23, Section 17.3, p. 698 Practice Problems: 24–27, Section 17.3, p. 699 Practice Problems: 28–33, Section 17.3, p. 701 Section 17.3 Review: 1, 3–6, p. 704 Chapter 17 Review: 1, 3–6, 8, 12–20, 23, 24, 28, 29, pp. 720–721 Chapter 17 Test Unit 8 Review: 20, 21, 31, 32–36, 39, 43, 47, 49, 50, pp. 724–727

	Student Textbook	Assessment Options
30–D2.3k calculate equilibrium constants and concentrations for homogeneous systems and Brönsted–Lowry acids and bases (excluding buffers) when ■ concentrations at equilibrium are known ■ initial concentrations and one equilibrium concentration are known ■ the equilibrium constant and one equilibrium concentration are known **Note:** Examples that require the application of the quadratic equation are excluded; however, students may use this method in responding to open–ended questions.	The Relationship Between Conjugate Acid–Base Pairs, Section 17.3, p. 701 Sample Problem: Equilibrium Constants for Conjugate Acid–Base Pairs, Section 17.3, p. 702 Sample Problem: Predicting the Direction of an Acid–Base Reaction, Section 17.3, pp. 702–703	Practice Problems: 34–38, Section 17.3, p. 703 Section 17.3 Review: 1, 4, p. 704 Chapter 17 Review: 23, 28, 29, pp. 720–721 Chapter 17 Test Unit 8 Review: 20, 21, 27, 29, 31–39, 47, 49, 51, pp. 724–727
Outcomes for Science, Technology and Society (Emphasis on nature of science)		
30–D2.1sts develop an understanding that technological development may involve the creation of prototypes and testing, as well as application of knowledge from related scientific and interdisciplinary fields by ■ *analyzing, on the basis of chemical principles, the application of equilibrium in, e.g.,* *– industrial processes or medical sciences* *– antacid tablets, buffering in living systems* *– acid precipitation.*	Chapter 17 Launch Lab: Buffering Ground Water: A Delicate Balance, p. 679 Connections: Buffers in the Blood, Section 17.4, p. 717	Chapter 17 Launch Lab: Buffering Ground Water: A Delicate Balance: 1–3, p. 679 Connections: Buffers in the Blood: 1–3, Section 17.4, p. 717
Skill Outcomes (Focus on scientific inquiry)		
Initiating and Planning		
30–D2.1s ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by ■ designing an experiment to show qualitative equilibrium shifts in concentration under a given set of conditions ■ describing procedures for safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information.	Investigation 17.B: Preparing a Buffer and Investigating Its Properties, Section 17.4, pp. 710–712	Investigation 17.B: Preparing a Buffer and Investigating Its Properties: 1–8, Section 17.4, pp. 710–712
Performing and Recording		
30–D2.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by ■ performing an experiment to show equilibrium shifts in concentration	Investigation 17.A: Determining K_a for Ethanoic Acid, Section 17.2, pp. 694–695 Investigation 17.B: Preparing a Buffer and Investigating Its Properties, Section 17.4, pp. 710–712	Investigation 17.A: Determining K_a for Ethanoic Acid: 1–8, Section 17.2, pp. 694–695 Investigation 17.B: Preparing a Buffer and Investigating Its Properties: 1–8, Section 17.4, pp. 710–712

	Student Textbook	Assessment Options
Analyzing and Interpreting		
30–D2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions by ■ using experimental data to calculate equilibrium constants.	Investigation 17.A: Determining K_a for Ethanoic Acid, Section 17.2, pp. 694–695 Thought Lab 17.1: Analyzing a Weak Acid–Strong Base Titration, Section 17.4, p. 709 Investigation 17.B: Preparing a Buffer and Investigating Its Properties, Section 17.4, pp. 710–712	Investigation 17.A: Determining K_a for Ethanoic Acid: 1–8, Section 17.2, pp. 694–695 Thought Lab 17.1: Analyzing a Weak Acid–Strong Base Titration: 1–4, Section 17.4, p. 709 Investigation 17.B: Preparing a Buffer and Investigating Its Properties: 1–8, Section 17.4, pp. 710–712
Communication and Teamwork		
30–D2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results by ■ *using advanced menu features within a word processor to develop a group report on equilibrium applications in Alberta industries.*	Thought Lab 17.1: Analyzing a Weak Acid–Strong Base Titration, Section 17.4, p. 709 Investigation 17.B: Preparing a Buffer and Investigating Its Properties, Section 17.4, pp. 710–712	Thought Lab 17.1: Analyzing a Weak Acid–Strong Base Titration: 1–4, Section 17.4, p. 709 Investigation 17.B: Preparing a Buffer and Investigating Its Properties: 6, 7, Section 17.4, pp. 710–712

CHAPTER 17 ACID-BASE EQUILIBRIUM SYSTEMS

Curriculum Correlation

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

	Student Textbook	Assessment Options
Outcomes for Knowledge		
30–D1.1k define equilibrium and state the criteria that apply to a chemical system in equilibrium, i.e., closed system, constancy of properties, equal rates of forward and reverse reactions	Chemical Equilibrium, Section 16.1, p. 634 Conditions That Apply to All Equilibrium Systems, Section 16.1, pp. 636–637	Questions for Comprehension: 1–3, Section 16.1, p. 636 Section 16.1 Review: 1–11, p. 638 Chapter 16 Review: 1–3, 6, 7, 22, pp. 676–677 Chapter 16 Test Unit 8 Review: 1–3, 5–11, 20, pp. 724–727
30–D1.2k identify, write and interpret chemical equations for systems at equilibrium	The Law of Chemical Equilibrium, Section 16.2, pp. 639–641 Equilibrium Law Expression, Section 16.2, p. 641 Sample Problem: Writing Equilibrium Expression for Homogeneous Chemical Reactions, Section 16.2, p. 641 Sample Problem: Calculating an Equilibrium Constant, Section 16.2, pp. 642–643 Sample Problem: Calculating an Equilibrium Concentration, Section 16.2, p. 643	Practice Problems: 1–5, Section 16.2, p. 641 Practice Problems: 6–10, Section 16.2, p. 644 Section 16.2 Review: 1–8, p. 655 Chapter 16 Review: 4, 5, 8–12, 14–19, 24, pp. 676–677 Chapter 16 Test Unit 8 Review: 2–4, 7–10, 12, 19, 26–31, 33, 37, 38, 41, 50, 52, 53, pp. 724–727
30–D1.3k predict, qualitatively, using Le Châtelier's principle, shifts in equilibrium caused by changes in temperature, pressure, volume, concentration or the addition of a catalyst, and describe how these changes affect the equilibrium constant	Le Châtelier's Principle, Section 16.2, pp. 646–647 Sample Problem: Temperature and the Extent of a Reaction, Section 16.2, p. 640 Sample Problem: Using Le Châtelier's Principle, Section 16.2, p. 651	Practice Problems: 11–15, Section 16.2, pp. 649–650 Practice Problems: 16–20, Section 16.2, pp. 651 Section 16.2 Review: 3, 5–8, p. 655 Chapter 16 Review: 10–14, 18, 19, 24, pp. 676–677 Chapter 16 Test Unit 8 Review: 9, 26–30, 34, pp. 724–727
30–D1.4k define K_c and write equilibrium law expressions for given chemical equations, using lowest whole–number coefficients	The Law of Chemical Equilibrium, Section 16.2, pp. 639–641 Equilibrium Law Expression, Section 16.2, p. 641 Sample Problem: Writing Equilibrium Expression for Homogeneous Chemical Reactions, Section 16.2, p. 641 Sample Problem: Using Stoichiometry to Calculate K_c, Section 16.3, pp. 657–658 Sample Problem: Using the Approximation Method, Section 16.3, pp. 659–660	Practice Problems: 1–5, Section 16.2, p. 641 Practice Problems: 6–10, Section 16.2, p. 644 Section 16.2 Review: 1–8, p. 655 Practice Problems: 21–24, Section 16.3, p. 658 Practice Problems: 25–29, Section 16.3, p. 660 Section 16.3 Review: 1–5, p. 665 Chapter 16 Review: 3, 5–7, pp. 676–677 Chapter 16 Test Unit 8 Review: 4, 7, 10, 11, 26–30, pp. 724–727

	Student Textbook	Assessment Options
30–D1.5k describe Brönsted–Lowry acids as proton donors and bases as proton acceptors	**Understanding Acids and Bases, Section 17.2, p. 684** **Sample Problem: Conjugate Acid–Base Pairs, Section 17.2, pp. 686–687**	**Questions for Comprehension: 3–5, Section 17.2, p. 686** **Practice Problems: 1–4, Section 17.2, p. 687** **Section 17.3 Review: 1–6, p. 704** **Chapter 17 Test** Unit 8 Review: 16–19, 21–23, 25, 31–39, 44–47, 50, 52, 53, pp. 724–727
30–D1.6k write Brönsted–Lowry equations and predict whether reactants or products are favoured for acid–base equilibrium reactions (including indicators, polyprotic acids, and polyprotic bases)	**Predicting the Direction of Reaction for an Acid–Base Reaction, Section 17.2, p. 689** **Sample Problem: Predicting the Direction of an Acid–Base Reaction, Section 17.2, p. 689**	**Practice Problems: 8–10, Section 17.2, p. 690** **Section 17.2 Review: 1–4, p. 690** **Practice Problems: 11–13, Section 17.3, p. 692** **Chapter 17 Review: 7, p. 720–721** **Chapter 17 Test** Unit 8 Review: 16–19, 21–23, 25, 31–39, 44–47, 50, 52, 53, pp. 724–727
30–D1.7k identify polyprotic acids, polyprotic bases, conjugate pairs and amphiprotic substances	**Both an Acid and a Base: Amphiprotic Substances, Section 17.2, p. 688** **Sample Problem: An Amphiprotic Ion, Section 17.2, p. 688**	**Practice Problems: 5–7, Section 17.2, p. 688** **Section 17.2 Review: 3, p. 690** **Chapter 17 Test** Unit 8 Review: 16–19, 23, 25, 31, 34, pp. 726–729
30–D1.8k define a buffer as relatively large amounts of a weak acid and its conjugate base in equilibrium that maintain a relatively constant pH when small amounts of acid or base are added	**Buffer Solutions, Section 17.4, pp. 712–713**	**Questions for Comprehension: 1, 2, Section 17.1, p. 682** **Section 17.4 Review: 6–8, p. 718** **Chapter 17 Review: 11, 26, pp. 720–721** **Chapter 17 Test** Unit 8 Review: 24, 25, 43, 47, pp. 724–727
30–D1.9k sketch and qualitatively interpret titration curves of monoprotic and polyprotic acids and bases identifying equivalence points and regions of buffering for weak acid–strong base, strong acid–weak base, and strong acid–strong base.	Thought Lab 16.1: Finding and Equilibrium Law, Section 16.3, p. 661 **Titration Curves and Buffers, Section 17.4, pp. 705–708**	Thought Lab 16.1: Finding and Equilibrium Law: 1–7, Section 16.3, p. 661 **Questions for Comprehension: 9–12, Section 17.4, p. 710** **Section 17.4 Review: 1–8, p. 718** **Chapter 17 Review: 25, pp. 720–721** **Chapter 17 Test** Unit 8 Review: 39, 44–47, pp. 724–727
Outcomes for Science, Technology and Society (Emphasis on nature of science)		
30–D1.1sts demonstrate an understanding that the goal of science is knowledge about the natural world by ■ *applying equilibrium theories and principles to analyze a variety of phenomena, e.g.,* – *carbon dioxide escaping from an open bottle/can of carbonated beverage* – *role of the oceans in the carbon cycle* – *solubility of oxygen gas in lake water* – *acid precipitation (deposition)* – *blood gases in deep–sea diving* – *buffers in living systems*	Chapter 16 Launch Lab: The Chemical Blues, p. 633 Connections: The Development of Equilibrium Theories, Section 16.2, p. 645	Chapter 16 Launch Lab: The Chemical Blues: 1, 2, p. 633 Connections: The Development of Equilibrium Theories, Section 16.2, p. 645 **Chapter 17 Review: 2, 21, 22, 27–29, pp. 720–721** Unit 8 Review: 13–15, 39–53, pp. 724–727

	Student Textbook	Assessment Options
30–D1.2sts demonstrate an understanding that scientific knowledge and theories develop through hypotheses, the collection of evidence through experimentation and the ability to provide explanations, e.g., *research how equilibrium theories and principles developed*	Chapter 16 Launch Lab: The Chemical Blues, p. 633 Connections: The Development of Equilibrium Theories, Section 16.2, p. 645	Chapter 16 Launch Lab: The Chemical Blues: 1, 2, p. 633 Connections: The Development of Equilibrium Theories: 1–3, Section 16.2, p. 645 **Chapter 17 Review: 2, 21, 22, pp. 720–721** Unit 8 Review: 13–15, 39–53, pp. 724–727
30–D1.3sts demonstrate an understanding that the goal of technology is to provide solutions to practical problems by ■ *analyzing how equilibrium principles have been applied in industrial processes, e.g.,* – *the Haber–Bosch process for making ammonia* – *the Solvay process for making sodium carbonate* – production of methanol.	Chapter 16 Launch Lab: The Chemical Blues, p. 633 Connections: The Development of Equilibrium Theories, Section 16.2, p. 645 Investigation 16.B: Disturbing Equilibrium, Section 16.2, pp. 652–654	Chapter 16 Launch Lab: The Chemical Blues: 1, 2, p. 633 Connections: The Development of Equilibrium Theories: 1–3, Section 16.2, p. 645 Investigation 16.B: Disturbing Equilibrium: 1–8, Section 16.2, pp. 652–654 Section 16.4 Review: 1–4, p. 674 **Section 17.1 Review: 1–6, p. 683** Unit 8 Review: 13–15, 39–53, pp. 724–727
Skill Outcomes (Focus on scientific inquiry)		
Initiating and Planning		
30–D1.1s ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by ■ predicting variables that can cause a shift in equilibrium ■ designing an experiment to show equilibrium shifts, e.g., *colour change, temperature change, precipitation* ■ describing procedures for safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information ■ *designing a buffering system.*	Chapter 16 Launch Lab: The Chemical Blues, p. 633 Investigation 16.A: Modelling Equilibrium, Section 16.1, pp. 635–636 Investigation 16.B: Disturbing Equilibrium, Section 16.2, pp. 652–654 Investigation 16.C: Using Experimental Data to Determine an Equilibrium Constant, Section 16.3, pp. 662–665	Chapter 16 Launch Lab: The Chemical Blues: 1, 2, p. 633 Investigation 16.A: Modelling Equilibrium: 1–10, Section 16.1, pp. 635–636 Investigation 16.B: Disturbing Equilibrium: 1–8, Section 16.2, pp. 652–654 Investigation 16.C: Using Experimental Data to Determine an Equilibrium Constant: 1–4, Section 16.3, pp. 662–665 Unit 8 Review: 39, 40, 44, 47, pp. 724–727
Performing and Recording		
30–D1.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by ■ performing an experiment to test, qualitatively, predictions of equilibrium shifts, e.g., *colour change, temperature change, precipitation, and gas production* ■ *preparing a buffer to investigate the relative abilities of a buffer and a control; i.e., water, to resist a pH change when a small amount of strong acid or strong base is added.*	Investigation 16.A: Modelling Equilibrium, Section 16.1, pp. 635–636 Investigation 16.B: Disturbing Equilibrium, Section 16.2, pp. 652–654 Investigation 16.C: Using Experimental Data to Determine an Equilibrium Constant, Section 16.3, pp. 662–665	Investigation 16.A: Modelling Equilibrium: 1–10, Section 16.1, pp. 635–636 Investigation 16.B: Disturbing Equilibrium: 1–8, Section 16.2, pp. 652–654 Investigation 16.C: Using Experimental Data to Determine an Equilibrium Constant: 1–4, Section 16.3, pp. 662–665 Unit 8 Review: 39, 40, 44, 47, pp. 724–727
Analyzing and Interpreting		
30–D1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions by ■ writing the equilibrium law expression for a given equation ■ analyzing, qualitatively, the changes in concentrations of reactants and products after an equilibrium shift ■ interpreting data from a graph to determine when equilibrium is established, and determining the cause of a stress on the system.	Investigation 16.B: Disturbing Equilibrium, Section 16.2, pp. 652–654 Thought Lab 16.1: Finding an Equilibrium Law, Section 16.3, p. 661 Investigation 16.C: Using Experimental Data to Determine an Equilibrium Constant, Section 16.3, pp. 662–665	Investigation 16.B: Disturbing Equilibrium: 1–8, Section 16.2, pp. 652–654 Thought Lab 16.1: Finding an Equilibrium Law, Section 16.3, p. 661 Investigation 16.C: Using Experimental Data to Determine an Equilibrium Constant: 1–4, Section 16.3, pp. 662–665 Unit 8 Review: 10, 26–30, 32–34, 39, 47, 49–53, pp. 724–727

	Student Textbook	Assessment Options
Communication and Teamwork		
30–D1.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results by ■ *working collaboratively with team members to develop an illustration and explanation of reversible reactions* ■ *using advanced menu features within a word processor to develop a group report on equilibrium systems.*	Investigation 16.B: Disturbing Equilibrium, Section 16.2, pp. 652–654	Investigation 16.B: Disturbing Equilibrium: 1–8, Section 16.2, pp. 652–654

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

	Student Textbook	Assessment Options
Outcomes for Knowledge		
30–D2.1k recall the concepts pH and hydronium ion concentration, pOH and hydroxide ion concentration in relation to acids and bases	Describing Acidic and Basic Solutions, Unit 8 Preparation, pp. 630–631	Chapter 16 Review: 23, pp. 676–677 **Chapter 17 Review: 1, 3–6, 8, 13, 15, 19, pp. 720–721** **Chapter 17 Test** Unit 8 Review: 31, 32, 34, 36, 39, 43, 47, 49, 50, pp. 724–727
30–D2.2k define K_w , K_a , K_b and use these to determine pH, pOH, $[H_3O^+]$, $[OH^-]$ of acidic and basic solutions	**Acid–Base Equilibriums, Section 17.3, p. 691** **Sample Problem: Acid Ionization Expressions, Section 17.3, p. 691** **Sample Problem: Determining K_a and Percent Ionization, Section 17.3, pp. 692–693** **The Ion Product Constant for Water, Section 17.3, pp. 695–696** **The Base Ionization Constant K_b, Section 17.3, pp. 696–697** **Sample Problem: Calculating K_b for a Weak Base, Section 17.3, p. 697** **Calculating the pH of a Solution of a Weak Acid or a Weak Base, Section 17.3, p. 698** **Sample Problem: Calculating the pH of a Weak Acid, Section 17.3, p. 699** **Sample Problem: Calculating the pH of a Weak Base, Section 17.3, p. 700**	**Practice Problems: 11–13, Section 17.3, p. 692** **Practice Problems: 14–18, Section 17.3, p. 693** **Questions for Comprehension: 6–8, Section 17.3, p. 696** **Practice Problems: 19–23, Section 17.3, p. 698** **Practice Problems: 24–27, Section 17.3, p. 699** **Practice Problems: 28–33, Section 17.3, p. 701** **Section 17.3 Review: 1, 3–6, p. 704** **Chapter 17 Review: 1, 3–6, 8, 12–20, 23, 24, 28, 29, pp. 720–721** **Chapter 17 Test** Unit 8 Review: 20, 21, 31, 32–36, 39, 43, 47, 49, 50, pp. 724–727

	Student Textbook	Assessment Options
30–D2.3k calculate equilibrium constants and concentrations for homogeneous systems and Brönsted–Lowry acids and bases (excluding buffers) when ■ concentrations at equilibrium are known ■ initial concentrations and one equilibrium concentration are known ■ the equilibrium constant and one equilibrium concentration are known **Note:** Examples that require the application of the quadratic equation are excluded; however, students may use this method in responding to open–ended questions.	**The Relationship Between Conjugate Acid–Base Pairs, Section 17.3, p. 701** **Sample Problem: Equilibrium Constants for Conjugate Acid–Base Pairs, Section 17.3, p. 702** **Sample Problem: Predicting the Direction of an Acid–Base Reaction, Section 17.3, pp. 702–703**	**Practice Problems: 34–38, Section 17.3, p. 703** **Section 17.3 Review: 1, 4, p. 704** **Chapter 17 Review: 23, 28, 29, pp. 720–721** **Chapter 17 Test** Unit 8 Review: 20, 21, 27, 29, 31–39, 47, 49, 51, pp. 724–727
Outcomes for Science, Technology and Society (Emphasis on nature of science)		
30–D2.1sts develop an understanding that technological development may involve the creation of prototypes and testing, as well as application of knowledge from related scientific and interdisciplinary fields by ■ *analyzing, on the basis of chemical principles, the application of equilibrium in, e.g.,* *– industrial processes or medical sciences* *– antacid tablets, buffering in living systems* *– acid precipitation.*	**Chapter 17 Launch Lab: Buffering Ground Water: A Delicate Balance, p. 679** **Connections: Buffers in the Blood, Section 17.4, p. 717**	**Chapter 17 Launch Lab: Buffering Ground Water: A Delicate Balance: 1–3, p. 679** **Connections: Buffers in the Blood: 1–3, Section 17.4, p. 717**
Skill Outcomes (Focus on scientific inquiry)		
Initiating and Planning		
30–D2.1s ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by ■ designing an experiment to show qualitative equilibrium shifts in concentration under a given set of conditions ■ describing procedures for safe handling, storage and disposal of materials used in the laboratory, with reference to WHMIS and consumer product labelling information.	**Investigation 17.B: Preparing a Buffer and Investigating Its Properties, Section 17.4, pp. 710–712**	**Investigation 17.B: Preparing a Buffer and Investigating Its Properties: 1–8, Section 17.4, pp. 710–712**
Performing and Recording		
30–D2.2s conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by ■ performing an experiment to show equilibrium shifts in concentration	**Investigation 17.A: Determining K_a for Ethanoic Acid, Section 17.2, pp. 694–695** **Investigation 17.B: Preparing a Buffer and Investigating Its Properties, Section 17.4, pp. 710–712**	**Investigation 17.A: Determining K_a for Ethanoic Acid: 1–8, Section 17.2, pp. 694–695** **Investigation 17.B: Preparing a Buffer and Investigating Its Properties: 1–8, Section 17.4, pp. 710–712**

	Student Textbook	Assessment Options
Analyzing and Interpreting		
30–D2.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions by ■ using experimental data to calculate equilibrium constants.	**Investigation 17.A: Determining K_a for Ethanoic Acid, Section 17.2, pp. 694–695** **Thought Lab 17.1: Analyzing a Weak Acid–Strong Base Titration, Section 17.4, p. 709** **Investigation 17.B: Preparing a Buffer and Investigating Its Properties, Section 17.4, pp. 710–712**	**Investigation 17.A: Determining K_a for Ethanoic Acid: 1–8, Section 17.2, pp. 694–695** **Thought Lab 17.1: Analyzing a Weak Acid–Strong Base Titration: 1–4, Section 17.4, p. 709** **Investigation 17.B: Preparing a Buffer and Investigating Its Properties: 1–8, Section 17.4, pp. 710–712**
Communication and Teamwork		
30–D2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results by ■ *using advanced menu features within a word processor to develop a group report on equilibrium applications in Alberta industries.*	**Thought Lab 17.1: Analyzing a Weak Acid–Strong Base Titration, Section 17.4, p. 709** **Investigation 17.B: Preparing a Buffer and Investigating Its Properties, Section 17.4, pp. 710–712**	**Thought Lab 17.1: Analyzing a Weak Acid–Strong Base Titration: 1–4, Section 17.4, p. 709** **Investigation 17.B: Preparing a Buffer and Investigating Its Properties: 6, 7, Section 17.4, pp. 710–712**