Student-Based Performance Standards

Chemistry 30

Alberta Government

This document was written primarily for:

Students	✓
Teachers	✓ of Chemistry 30
Administrators	✓
Parents	
General Audience	
Others	

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Introduction

The Chemistry 30 Student-Based Performance Standards document is designed to be a tool for the classroom teacher. **This document is not the Program of Studies.** Rather, it is a document intended to help teachers identify behaviours that may be exhibited by students at the *acceptable standard* and at the *standard of excellence* for this course. These lists of behaviours are neither prescriptive nor exhaustive.

The relative numbers of statements are not an indication of the time that is required for each behaviour statement. Teachers should be guided by the Program of Studies, which indicates the times for each of the four units. Units A and C should each be allotted approximately 20% of the course time, while Units B and D should each be allotted approximately 30% of the course time. In addition, approximately 45% of the course expectations will be at the *acceptable standard*, between 25% and 30% intermediate between the *acceptable standard* and the *standard of excellence*, and approximately 25% will be at the *standard of excellence*. Further details can be found in the *Chemistry 30 Information Bulletin*.

Many of these standards are directly related to laboratory activities that are best experienced directly by the student. Some of these could be replaced by teacher demonstrations, multimedia presentations, or digital simulations, but direct student laboratory activity should be maximized, and other substitutes should be used only when direct experience is not possible for safety or environmental reasons.

Experimental design, including hypothesis testing, is an integral part of all four units in Chemistry 30, and several of the related standards are to be found in each and every unit of the course.

Some of these behaviours cannot be adequately assessed in a paper-and-pencil format, especially if the assessment instrument is 100% machine-scored. However, they are part of the Program of Studies, and should be assessed as part of the school-awarded mark in Chemistry 30.

Chemistry 30 General Outcome A1 *Students will* **determine and interpret energy changes in chemical reactions.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	**Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:**
• state that changes in temperature correspond to changes in kinetic energy • calculate any variable in the equation $Q = mc\Delta t$	• explain that changes in temperature are dependent upon the specific heat capacity of the substance when mass and heat energy are constant and use this to predict, qualitatively, relative changes in temperature for two substances
• state that bond energy in hydrocarbons originated in the Sun	
• state that changes in enthalpy (ΔH) correspond to changes in bonding and are measured in kilojoules (kJ) • state that molar enthalpy refers to the change in enthalpy when 1 mole of a substance is produced or consumed in a chemical reaction and is communicated using units of kJ/mol	• classify changes in enthalpy as changes in intermolecular bonding (link to melting and boiling point, and solubility in Unit C) or changes in intramolecular bonding
• determine the molar enthalpy of reaction for a substance when the balanced equation and the enthalpy of reaction are given • use the appropriate sign to designate an exothermic or endothermic enthalpy change or molar enthalpy of reaction	• determine the molar enthalpy of reaction for a substance when given an unbalanced or implied chemical reaction (where only reactants are given or reaction is described e.g., combustion of methane) and the enthalpy of reaction
• recognize that enthalpy is considered a reactant in an endothermic process and a product in an exothermic process • convert ΔH notation into a balanced equation where energy is a term in the equation	• determine the position of the energy term for an implied chemical reaction from a description of the change in the kinetic energy of the surroundings
• calculate the energy change or mass of substance produced or consumed in a reaction when the enthalpy change of the reaction is given and the coefficient of the substance is equal to 1	• calculate the energy change or mass of substance produced or consumed in a reaction when the enthalpy change of the reaction is given and the coefficient of the substance is **not** equal to 1 • calculate the energy change or mass of substance produced or consumed when the enthalpy of reaction must be determined

This list is a description of behaviours that illustrate performance at particular standards based on the Chemistry 30 Program of Studies. This list is neither prescriptive nor exhaustive. This document is NOT the PROGRAM OF STUDIES.

Chemistry 30 General Outcome A1 ***Students will* determine and interpret energy changes in chemical reactions.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	**Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:**
• state that the standard molar enthalpies of formation are measured under standard conditions • state that the standard molar enthalpy of formation is 0 kJ/mol for all elements in their standard states • state how the standard molar enthalpy of decomposition is related to the standard molar enthalpy of formation for a compound • write a balanced equation that includes energy either as a term in the equation or in ΔH notation from the value of the standard molar enthalpy of formation, $\Delta_f H$ • sketch an enthalpy diagram for chemical reaction from the value of $\Delta_f H$	• calculate the value of ΔH for an implied chemical reaction or an unbalanced chemical equation, or a reaction occurring under non-standard conditions when all the molar enthalpies of formation are given in the Data Booklet • calculate the value of ΔH for a combustion reaction that occurs under non-standard conditions
• calculate the value of ΔH for a balanced equation when the molar enthalpies of formation of all reactants and products are given	• calculate the molar enthalpy of formation for a compound when the value of ΔH for the balanced equation and the values of $\Delta_f H$ for all other compounds in the equation are given
• calculate the enthalpy change for a given balanced equation when a series of simple related equations are given with the associated values of ΔH	• analyze a series of related equations with associated values of ΔH to calculate the enthalpy change for a balanced equation that may include fractional coefficients
• recognize that endothermic reactions cause the calorimeter water to decrease in temperature and that exothermic reactions cause the calorimeter water to increase in temperature and use this knowledge when calculating molar enthalpies of reaction	• calculate the molar enthalpy of reaction when given empirical data (mass or volume and concentration of reactant used) from a simple polystyrene cup calorimetry experiment
• state the assumptions made when polystyrene cup calorimetry experiments are performed • calculate the enthalpy change when given data from a simple polystyrene cup calorimetry experiment • calculate the molar enthalpy of reaction when given data from a simple polystyrene cup calorimetry experiment and the moles of reactant consumed	• determine when the energy change of a calorimeter cannot be ignored and must be included in the calculation • calculate the molar enthalpy of reaction that includes the energy change of the calorimeter when given data for a calorimetry experiment
• interpret given empirical data to calculate the enthalpy change for a chemical reaction	• evaluate when to use calorimeters of different designs

Chemistry 30 General Outcome A1 ***Students will*** **determine and interpret energy changes in chemical reactions.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	**Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:**

• identify that liquid water and carbon dioxide are reactants in photosynthesis
• identify that liquid water and carbon dioxide are products of cellular respiration
• identify that gaseous water and carbon dioxide are products of hydrocarbon combustion in an open system
• identify that liquid water and carbon dioxide are products of hydrocarbon combustion in a closed system
• identify that photosynthesis is an endothermic process
• identify both cellular respiration and hydrocarbon combustion as exothermic processes
• classify reactions as endothermic or exothermic on the basis of the
  ◦ ΔH or $\Delta_r H$ value
  ◦ position of the energy term in a chemical equation
  ◦ effect of the reaction on the surroundings
  ◦ enthalpy diagram for the reaction
	• explain the enthalpy difference between cellular respiration and glucose combustion in an open system

• describe a simple experiment to compare the molar enthalpy change of two or more fuels	• design an experiment to compare the molar enthalpy change of two or more fuels that includes a detailed procedure and a list of required materials (reagents and apparatus)
• identify manipulated, responding, and controlled variables given the analysis and procedure	• when given a statement of a hypothesis, identify the major variables and suitable reagents to test this hypothesis
• plot experimental data given manipulated and responding variables, and insert lines of best fit that may be either straight or curved	• analyze a plot of experimental data, derive quantities from straight lines of best fit using slope and intercept and describe qualitatively the relationship between the variables based on the shape of the line of best fit
• interpret WHMIS symbols on laboratory reagents, and describe how to handle, store, and dispose of these materials	• identify all measurements that must be made in a calorimetry experiment in order to calculate the molar enthalpy of reaction • explicitly explain how experimental observations will be analyzed • suggest improvements to an experimental design to study the molar enthalpy of reaction

Chemistry 30 General Outcome A1 ***Students will*** **determine and interpret energy changes in chemical reactions.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	**Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:**
• follow instructions and collect data using available equipment for a simple calorimetry experiment • measure changes in temperature in a calorimeter with a thermometer or a temperature probe • for a given reaction, sketch an enthalpy diagram, with a suitable title, labelling the ◦ *x*-axis ◦ *y*-axis with appropriate units ◦ reactants ◦ products ◦ enthalpy change with both the appropriate sign and units • convert one format of communicating enthalpy change to another (e.g., a molar enthalpy of reaction to an enthalpy diagram)	
• rank reactions as to change in enthalpy (e.g., most endothermic to least endothermic) when all reactions have the enthalpy change in the same format with the same sign	• rank reactions as to change in enthalpy (e.g., most endothermic to most exothermic) when given different formats for communicating the enthalpy change
• work collaboratively in a group	• take a positive leadership role in group activities
• express calculated answers with appropriate significant digits	• when collecting data, express measured values with appropriate significant digits
• rely on the use of algorithms and formulas to solve problems	• choose the most efficient way of solving problems, using general methods such as unit analysis
• select the appropriate technological solution to an energy conversion problem	• explain and evaluate different technological solutions to an energy conversion problem
• identify an intended and an unintended consequence of an energy conversion	• evaluate the consequences of a given energy conversion

Chemistry 30 General Outcome A2 ***Students will*** **explain and communicate energy changes in chemical reactions.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	**Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:**
• define activation energy as the energy barrier that must be overcome for a chemical reaction to occur	
• state that energy is absorbed to break bonds • state that energy is released when bonds form • state that the products of an exothermic reaction have less enthalpy than the reactants • state that the products of an endothermic reaction have more enthalpy than the reactants	• explain in terms of changes in bonding why an exothermic reaction is accompanied by a release of energy • explain in terms of changes in bonding why an endothermic reaction absorbs energy from the surroundings

• label enthalpy diagrams, including
  ∘ reactants
  ∘ products
  ∘ activation energy (E_a)
  ∘ enthalpy change (ΔH)
• from a labelled enthalpy diagram, determine the value of E_a or ΔH for the forward reaction
	• from a labelled enthalpy diagram, determine the value of E_a for the reverse reaction
	• sketch and label an enthalpy diagram from a balanced equation that includes energy as a term or a ΔH value

• state that catalysts
  ∘ increase reaction rates
  ∘ provide alternate pathways for chemical change with a lower E_a
  ∘ do not affect the value of ΔH
• from a labelled enthalpy diagram, distinguish between the pathways of a catalyzed and an uncatalyzed reaction	

• identify manipulated, responding, and controlled variables given the analysis and procedure • interpret WHMIS symbols on laboratory reagents, and describe how to handle, store, and dispose of these materials	• when given a statement of a hypothesis, identify the major variables and suitable reagents to test this hypothesis • identify all measurements that must be made in an experimental design • explicitly explain how experimental observations will be analyzed • suggest improvements to an experimental design
• for a given reaction, sketch a labelled enthalpy diagram, including the value of E_a for the forward reaction	• for a given reaction, sketch a labelled enthalpy diagram, including the value of E_a for both the forward and the reverse reactions

Chemistry 30 General Outcome A2 ***Students will*** **explain and communicate energy changes in chemical reactions.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:
• use an enthalpy diagram to determine the value of ΔH for a given reaction • qualitatively indicate the sources of discrepancies between predicted and actual enthalpy outputs for a given energy conversion	• use a series of enthalpy diagrams to determine the value of ΔH for a net reaction • calculate the efficiency of a thermal conversion device using Hess' Law and calorimetric data • qualitatively indicate methods of reducing discrepancies between predicted and actual enthalpy outputs for a given energy conversion
• work collaboratively in a group	• take a positive leadership role in group activities
• express calculated answers with appropriate significant digits • rely on the use of algorithms and formulas to solve problems	• when collecting data, express measured values with appropriate significant digits • choose the most efficient way of solving problems, using general methods such as unit analysis
• select the appropriate technological solution to reduce the harmful consequences of an energy conversion • identify the risks and benefits of a technological solution from a variety of perspectives, including sustainability	• explain how a technological solution reduces the harmful consequences of an energy conversion • evaluate the limitations of a technological solution from a variety of perspectives, including sustainability

Chemistry 30 General Outcome B1 ***Students will*** **explain the nature of oxidation-reduction reactions.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:
• define oxidation as the loss of electrons • define reduction as the gain of electrons • identify oxidation or reduction from a balanced half-reaction • state that oxidizing agents gain electrons and reducing agents lose electrons	• relate operational and theoretical definitions of oxidation and reduction
• identify the oxidizing agent or reducing agent from a balanced equation	• identify oxidation or reduction from an unbalanced half-reaction, a skeletal equation, or a balanced net ionic equation
• identify oxidizing or reducing agents from a list of chemical species • state that the sum of oxidation numbers in a species is equal to the charge on the species	
• assign oxidation numbers to atoms in elements, monoatomic ions, and simple binary inorganic and organic compounds • identify a balanced half-reaction as oxidation or reduction on the basis of the position of the electrons in the equation	• assign oxidation numbers to elements in ionic compounds containing polyatomic ions and molecular substances containing more than two elements • construct balanced oxidation or reduction half-reactions from unbalanced half-reactions
• state that disproportionation involves both the gain and loss of electrons by a single reactant in a reaction • identify redox reactions from a net ionic equation that involves two half-reactions found in the Table of Selected Standard Electrode Potentials	• identify a disproportionation reaction in a series of redox equations
• identify the species gaining electrons and the species losing electrons in a common redox reaction (e.g., respiration, photosynthesis, corrosion) or involving species that appear in the Table of Selected Standard Electrode Potentials • state that the oxidation number of an element in the oxidizing agent decreases and the oxidation number of an element in the reducing agent increases in a redox reaction • identify the oxidizing agent and the reducing agent in a balanced redox equation that involves species found in the Table of Selected Standard Electrode Potentials	• identify redox equations by assigning oxidation numbers and inspecting for a change in oxidation number • identify the oxidizing agent and the reducing agent in an unfamiliar redox reaction (i.e., involving species that do **not** appear in the Table of Selected Standard Electrode Potentials) • determine the change in oxidation number for a species in a redox reaction • calculate and interpret changes in oxidation numbers in a reaction

Chemistry 30 General Outcome B1 ***Students will*** **explain the nature of oxidation-reduction reactions.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	**Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:**
• when given empirical data, identify oxidizing and reducing agents • rank the strength of oxidizing agents and reducing agents when given spontaneity results in a tabular form • rank the strength of oxidizing agents and reducing agents when given species in the Table of Selected Standard Electrode Potentials	• when given spontaneity results in the form of equations, rank the strengths of oxidizing agents and reducing agents • compare the strength of an unfamiliar oxidizing or reducing agent to those species present in the Table of Selected Electrode Potentials
• predict the net ionic equation including spontaneity when given species present in the Table of Selected Standard Electrode Potentials in either acidic or neutral solutions • compare the empirical observations (i.e., pH, conductivity, colour change, gas or precipitate formation) to predicted results when given the observations and the balanced net ionic equation	• predict the net ionic equation including spontaneity when given half-reactions with $E°$ values that are **not** in the Table of Selected Standard Electrode Potentials • predict the empirical observations (i.e., pH, conductivity, colour change, gas or precipitate formation) that accompany a spontaneous redox reaction • compare predicted evidence to empirical observations (i.e., pH, conductivity, colour change, gas or precipitate formation) when the balanced net ionic equation is **not** given
• determine the total number of electrons transferred in a redox reaction when given a skeletal equation • develop simple balanced half-reactions when given a skeletal equation in a neutral solution • balance a simple skeletal equation in a neutral solution using oxidation numbers	• develop balanced half-reactions when given a skeletal equation in an acidic solution • balance a skeletal equation in an acidic solution using oxidation numbers • balance a disproportionation reaction in a neutral or an acidic solution • determine the total number of electrons transferred in a disproportionation reaction
• determine the average volume of titrant used in a redox titration when given experimental data where no discrepant values are included • use stoichiometry to determine quantities of substances involved in a redox titration when given the balanced net ionic equation	• identify discrepant values in experimental data, and ignore these values when determining the average volume of titrant used in a redox titration • use stoichiometry to determine quantities of substances involved in a redox titration when given only the reactants **or** a skeletal equation

Chemistry 30 General Outcome B1 ***Students will*** **explain the nature of oxidation-reduction reactions.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:
• recognize the redox reaction that represents the corrosion of iron • describe the methods and devices used to prevent corrosion; i.e., physical coatings and cathodic protection	• predict the redox reaction that represents the corrosion of iron • predict conditions that would accelerate the corrosion process • explain how the methods and devices used prevent corrosion
• describe a simple experiment to determine the reactivity of various metals • identify manipulated, responding, and controlled variables given the analysis and procedure • plot experimental data given manipulated and responding variables, and insert a line of best fit that may be either straight or curved • interpret WHMIS symbols on laboratory reagents, and describe how to handle, store, and dispose of these materials	• design an experiment to determine the reactivity of various metals including a detailed procedure and a list of required materials (reagents and apparatus) • when given a statement of a hypothesis, identify the major variables and suitable reagents to test this hypothesis • analyze a plot of experimental data and describe qualitatively the relationship between the variables based on the shape of the line of best fit • identify all experimental data that must be collected in order to determine the reactivity of various metals • explicitly explain how experimental observations will be analyzed • suggest improvements to an experimental design to study the reactivity of various metals
• select the appropriate glassware to perform a redox titration • use the appropriate glassware to perform a titration (e.g., a pipette to measure sample volume) • identify the solutions that are used as the sample and the titrant when given a description of the titration • follow instructions and collect data using available equipment for a redox titration	• identify that titrations involving the permanganate ion are self-indicating, and identify the species responsible for the endpoint colour change
• work collaboratively in a group	• take a positive leadership role in group activities

Chemistry 30 General Outcome B1 ***Students will*** **explain the nature of oxidation-reduction reactions.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	**Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:**
• express calculated answers with appropriate significant digits • rely on the use of algorithms and formulas to solve problems	• when collecting data, express measured values with appropriate significant digits • choose the most efficient way of solving problems using general methods such as unit analysis
• identify an intended and an unintended consequence of a redox process • identify an electrochemical process in which the technology was developed prior to the scientific understanding of the process	• evaluate the consequences of a given redox process

Chemistry 30 General Outcome B2 *Students will* **apply the principles of oxidation-reduction to electrochemical cells.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:
• define anode, cathode, anion, cation, salt bridge or porous cup, electrolyte, external circuit, power supply, voltaic cell, and electrolytic cell in the context of a general cell (e.g., the cathode is the electrode at which reduction takes place)	
• identify anode, cathode, anion flow, cation flow, salt bridge or porous cup, electrolyte, external circuit, power supply in a diagram of an electrochemical cell composed of species found in the Table of Selected Standard Electrode Potentials • from a diagram, identify whether a cell is voltaic or electrolytic	• identify anode, cathode, anion flow, cation flow, salt bridge or porous cup, electrolyte, external circuit, power supply in a diagram of an unfamiliar electrochemical cell (i.e., composed of species **not** found in the Table of Selected Standard Electrode Potentials) when given half-reaction equations and the $E°$ value for each
• draw and label a diagram of a voltaic cell when given the standard cell notation for an electrochemical cell composed of simple redox couples (i.e., metal and metal ion) that appear in the Table of Selected Standard Electrode Potentials	• draw and label an electrochemical cell when given the standard cell notation for those electrochemical cells composed of unusual redox couples (e.g., those with an inert electrode)
• identify the similarities and differences between the operation of a voltaic cell and the operation of an electrolytic cell in terms of the ◦ site of reduction ◦ site of oxidation ◦ direction of cation flow ◦ direction of anion flow ◦ electron flow ◦ spontaneity of reaction ◦ value and sign of $E°_{cell}$ ◦ presence of a power supply, a voltmeter, or an electrical load	• analyze the design of electrochemical cells used as batteries or in electrolytic processes
• for a given half-reaction, identify at which electrode it would occur • predict the half-reaction that would occur at each electrode when given species that appear in the Table of Selected Standard Electrode Potentials	• for an incomplete half-reaction, identify at which electrode it would occur • for an unfamiliar electrochemical cell, predict the electrode at which a half-reaction would occur when given two half-reactions and the corresponding $E°$ values
• from empirical evidence, identify examples of anomalous results when predicted redox reactions did not occur	• recognize that the predicted reactions do not always occur (e.g., chloride anomaly, and aluminium pots with water)

Chemistry 30 General Outcome B2 ***Students will*** **apply the principles of oxidation-reduction to electrochemical cells.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	**Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:**
• state that standard conditions for the determination of reduction potentials are for a half-cell containing an electrolyte concentration of 1.0 mol/L at 25.00 °C and 101.325 kPa • state that the reference electrode is currently the standard hydrogen electrode and is assigned a reduction potential of 0.00 V and all other values are relative to this value	• determine the reduction potential for a reduction half-reaction given in the Table of Selected Standard Electrode Potentials when the reference electrode is changed to a given reduction half-reaction • explain why the $E°_{cell}$ value will not change if the reference electrode is changed

• for electrochemical cells composed of species found in the Table of Selected Standard Electrode Potentials, determine the standard cell potential for a cell when given
  ◦ the standard cell notation for the cell OR
  ◦ a labelled diagram of the cell
• determine the standard electrode potential for a half-reaction when given the $E°_{cell}$ value and the electrode potential for one half-reaction is found in the Table of Selected Standard Electrode Potentials
	• for unfamiliar electrochemical cells, determine the cell potential when given the relevant half-reactions and the corresponding electrode potentials
	• for an electrochemical cell, determine the identity of a redox couple in a half-cell when given the $E°_{cell}$ value and the identity of the other half-cell

• state that a positive $E°_{cell}$ value indicates a spontaneous reaction and a negative $E°_{cell}$ value indicates a nonspontaneous reaction • recognize that a negative $E°_{cell}$ value indicates the minimum voltage that must be applied to an electrolytic cell • predict the spontaneity of a reaction when given a labelled diagram of a cell	• for unfamiliar electrochemical cells, predict the spontaneity when given the relevant half-reactions and the corresponding $E°$ values

• calculate the mass, amounts, current or time in single voltaic cells and electrolytic cells when
  ◦ given the appropriate half-reaction
  ◦ given the balanced net redox equation, and
  ◦ the stoichiometric ratio is 1:1
	• calculate the mass, amounts, current or time in single voltaic cells and electrolytic cells when the
	  ◦ chemical reaction is described and/or
	  ◦ the stoichiometric ratio is **not** 1:1

This list is a description of behaviours that illustrate performance at particular standards based on the Chemistry 30 Program of Studies. This list is neither prescriptive nor exhaustive. This document is NOT the PROGRAM OF STUDIES.

Chemistry 30 General Outcome B2 ***Students will*** **apply the principles of oxidation-reduction to electrochemical cells.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	**Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:**
• describe a simple experiment to test for the products and measure the potential of an electrochemical cell • identify manipulated, responding, and controlled variables given the analysis and procedure • interpret WHMIS symbols on laboratory reagents, and describe how to handle, store, and dispose of these materials	• design an experiment to test for the products and measure the potential of an electrochemical cell, including a detailed procedure and a list of required materials (reagents and apparatus) • when given a statement of a hypothesis, identify the major variables and suitable reagents to test this hypothesis • identify all experimental data that must be collected in order to determine the identity of the products and the value of the standard cell potential • explicitly explain how experimental observations will be analyzed to confirm or refute the predictions • suggest improvements to an experimental design to study electrochemical cells
• follow instructions and collect data using available equipment to study electrochemical cells	• recognize the limitations of an experimental design used in the laboratory
• identify the products of electrochemical cells by predicting expected observations, including ∘ mass change of an electrode (electroplating or corrosion) ∘ colour change of an electrolyte ∘ pH change of an electrolyte ∘ production of a gas • compare predictions with actual observations of electrochemical cells	• predict how the expected observations could be tested in the laboratory (e.g., use of litmus paper to test pH, hydrogen pop test, re-ignition of a glowing splint) • identify the limitations of data collected and observations made for an electrochemical cell • explain the discrepancies between predicted and measured cell potential
• work collaboratively in a group	• take a positive leadership role in group activities
• express calculated answers with appropriate significant digits • rely on the use of algorithms and formulas to solve problems	• when collecting data, express measured values with appropriate significant digits • choose the most efficient way of solving problems, using general methods such as unit analysis
• identify an electrochemical process that has been developed to meet societal needs	• describe and explain how an electrochemical process has met societal needs • explain why an effective electrochemical process may or may not be used in society

Chemistry 30 General Outcome C1 ***Students will*** **explore organic compounds as a common form of matter.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	**Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:**
• define organic compounds as species composed of molecules containing carbon • recognize the inorganic carbon compounds, including ∘ carbonates ∘ cyanides of elements ∘ carbides ∘ oxides of carbon • identify and describe the uses, origins, and sources of common organic molecules such as ∘ methane ∘ methanol ∘ methanoic acid ∘ ethane ∘ ethanol ∘ ethanoic acid ∘ propane ∘ benzene ∘ octane ∘ polyethene ∘ glucose ∘ sucrose • recognize the differences among structural, condensed structural, and line diagrams	• recognize **unfamiliar** compounds containing carbon as being organic (e.g., aldehydes, ketones, amides, amines) • recognize that all hydrocarbon derivatives are classified as organic, including cyanides (e.g., $CH_3CN(l)$) and fully halogenated hydrocarbons (e.g., $CCl_4(l)$)
• identify aromatic compounds from line diagrams containing the benzene ring in either the Kekulé (alternating single and double bonds) or Thiele (hexagon with a circle within it) representation • identify aliphatic compounds from diagrams	• identify aromatic compounds when given expanded molecular formulas
• when given a diagram of the molecule, classify aliphatic compounds (both hydrocarbons and hydrocarbon derivatives) as saturated or unsaturated	• when given the IUPAC name of a compound, classify aliphatic compounds (both hydrocarbons and hydrocarbon derivatives) as saturated or unsaturated

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Chemistry 30 General Outcome C1 ***Students will*** **explore organic compounds as a common form of matter.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	**Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:**
• when given a diagram, provide the IUPAC name for aliphatic compounds that contain ◦ up to 10 carbons in the parent chain or ring ◦ only one functional group (e.g., double bond, triple bond, halogen, hydroxyl, carboxyl or ester)	• when given a diagram, provide the IUPAC name for aliphatic compounds that contain ◦ more than one type of alkyl branch ◦ a double or triple bond and one or more alkyl branches ◦ multiple occurrences of a halogen and/or hydroxyl functional group
• when given its IUPAC name, draw a diagram for an aliphatic compound that contains ◦ up to 10 carbons in the parent chain or ring ◦ one alkyl branch ◦ only one functional group (e.g., double bond, triple bond, halogen, hydroxyl, carboxyl or ester)	• when given its IUPAC name, draw a diagram for an aliphatic compound that contains ◦ more than one type of alkyl branch ◦ a double or triple bond and one or more alkyl branches ◦ multiple occurrences of a halogen and/or hydroxyl functional group
• when given a diagram, provide the IUPAC name for an aromatic compound that contains ◦ one alkyl branch ◦ one halogen, hydroxyl, or carboxyl group	• when given a diagram, provide the IUPAC name for aromatic compounds that contain ◦ more than one type of alkyl branch ◦ more than one halogen and/or hydroxyl functional group
• when given its IUPAC name, draw a diagram for an aromatic compound that contains ◦ one alkyl branch ◦ one halogen, hydroxyl, or carboxyl group	• when given its IUPAC name, draw a diagram for an aromatic compound that contains ◦ more than one alkyl branch ◦ more than one halogen ◦ a combination of alkyl branches, halogens and one hydroxyl or carboxyl group
• define *functional group* • provide a general formula to represent the functional group present in halogenated hydrocarbons, alcohols, acids, and esters • when given a diagram of an organic compound, identify the hydroxyl, carboxyl, ester linkage, or halogen functional group • when given a diagram of an organic compound, identify the family to which it belongs	• when given the IUPAC name of an organic compound, identify which functional group (hydroxyl, carboxyl, ester linkage, or halogen) is present • when given the diagram of an unfamiliar organic compound, identify multiple functional groups present • when given the IUPAC name of an organic compound, identify the family to which it belongs • associate general formulas for hydrocarbons with different classes of hydrocarbons, such as alkanes, cycloalkenes, etc.

Chemistry 30 General Outcome C1 ***Students will*** **explore organic compounds as a common form of matter.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:
• define structural isomers as compounds that have the same molecular formula but different structural formulas • when given diagrams, identify simple structural isomers (e.g., those within the same family) • when given the chemical formula, draw the structures of isomers from the same family • when given the IUPAC names or diagrams of the isomers and data on a physical property, identify the effect on the property of branching or the presence of a ring	• when given diagrams, identify isomers from different families (e.g., ethanoic acid and methyl methanoate, but-1-ene and cyclobutane) • when given a chemical formula, draw the structures of isomers from different families • when given the IUPAC names or diagrams of isomers, predict the effect of branching or the presence of a ring on a given physical property
• define homologous series • when given diagrams, identify members of a homologous series • when given the diagrams or IUPAC names of compounds from the same family, rank compounds based on boiling point • when given the diagram or IUPAC name of an aliphatic or aromatic compound, identify the likely solubility of the compound in water	• when given IUPAC names, identify members of a homologous series • when given diagrams or IUPAC names of compounds from the same family, explain the trend in boiling points • when given diagrams or IUPAC names of compounds with the same parent chain but different functional groups, rank the compounds based on boiling point and explain their ranking in terms of intermolecular forces • when given the diagram or IUPAC name, identify the likely solubility of the compound in a nonpolar solvent • explain the differences in solubility in water or a nonpolar solvent in terms of hydrogen bond formation and the interactions of other intermolecular forces

• describe the process of fractional distillation
• state that fractional distillation separates organic compounds based on boiling point
• when given the structural diagrams or IUPAC names of a number of hydrocarbons, predict the sequence in which they would be separated in a fractional distillation column
• describe the process of solvent extraction
• state that solvent extraction separates compounds based on solubility in a specific solvent
	• when given the structural diagrams or IUPAC names of a number of hydrocarbon derivatives, predict
	  ◦ the sequence in which they would be separated in a fractional distillation column
	  ◦ how they could be separated using polar and nonpolar solvents

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Chemistry 30 General Outcome C1 ***Students will*** **explore organic compounds as a common form of matter.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:
• describe a simple experiment to identify types of organic compounds or to separate a mixture of organic compounds based on boiling point	• design an experiment to identify organic compounds or to separate a mixture of organic compounds that includes a detailed procedure and a list of required materials (reagents and apparatus)
• identify manipulated, responding, and controlled variables given the analysis and procedure • plot experimental data given manipulated and responding variables, and insert a line of best fit that may be either straight or curved • interpret WHMIS symbols on laboratory reagents, and describe how to handle, store, and dispose of these materials	• when given a statement of a hypothesis, identify the major variables and suitable reagents to test this hypothesis • analyze a plot of experimental data, derive quantities from straight lines of best fit using slope and intercept, and describe qualitatively the relationship between the variables based on the shape of the lines of best fit • explicitly explain how experimental observations will be analyzed • suggest improvements to an experimental design to identify organic compounds or to separate a mixture of organic compounds
• build molecular models depicting the structures of common organic compounds containing ∘ up to 10 carbons in the parent chain or ring ∘ one alkyl branch ∘ only one functional group (e.g., double bond, triple bond, halogen, hydroxyl, carboxyl or ester) • build molecular models depicting the structures of common inorganic compounds such as carbon dioxide, water, and ammonia • follow instructions and collect data using available equipment to compare inorganic and organic compounds on the basis of ∘ solubility ∘ viscosity ∘ density ∘ conductivity ∘ reactivity • use appropriate IUPAC guidelines when writing the names and formulas of organic compounds	• build molecular models depicting the structure of compounds containing ∘ more than one type of alkyl branch ∘ a double or triple bond and one or more alkyl branches ∘ multiple occurrences of a halogen or hydroxyl functional group

Chemistry 30 General Outcome C1 ***Students will*** **explore organic compounds as a common form of matter.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:
• when given organized data of the properties of structural isomers, identify trends in the data	• when given data of the properties of structural isomers, predict the properties of isomers not included in the data
• when given evidence of the speed and extent of reaction with aqueous bromine or potassium permanganate, identify simple saturated and unsaturated aliphatic hydrocarbons	• when given evidence of reaction with aqueous bromine or potassium permanganate, identify saturated and unsaturated aliphatic hydrocarbon derivatives • when given diagrams or the IUPAC names, predict the results of a reaction of the organic compound with aqueous bromine or potassium permanganate
• work collaboratively in a group	• take a positive leadership role in group activities
• describe modern or traditional uses of organic compounds that meet or met a need in society and expand human capabilities	• explain how modern or traditional uses of organic compounds meet or met a need in society and expand human capabilities
• describe a discovery of a compound or a process in organic chemistry that has met a need in society	• explain how a discovery of a compound or a process in organic chemistry has met a need in society

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Chemistry 30 General Outcome C2 ***Students will*** **describe chemical reactions of organic compounds.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	**Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:**
• define and provide an example of each of the following reaction types: ∘ addition ∘ substitution ∘ elimination ∘ esterification ∘ combustion	
• when given balanced equations (with diagrams representing the organic molecules), classify the reaction as ∘ addition (simple reactions involving symmetrical addends) ∘ substitution (simple reactions involving halogens) ∘ elimination ∘ esterification ∘ combustion	• when given balanced equations (with either molecular formulas or IUPAC names), classify the reaction as ∘ addition (reactions involving asymmetrical addends) ∘ substitution (including simple nucleophiles) ∘ elimination ∘ esterification ∘ combustion ∘ incomplete combustion
• when given diagrams of the reactants, draw diagrams and provide IUPAC names for the products and balance the equations for the following reactions: ∘ addition (simple reactions involving symmetrical addends) ∘ substitution (simple reactions involving halogens) ∘ elimination (in a symmetrical molecule) ∘ esterification ∘ combustion	• when given molecular formulas of the reactants, draw diagrams and provide IUPAC names for the products and balance the equations for the following reactions: ∘ addition* (reactions involving asymmetrical addends) ∘ substitution (including simple nucleophiles) ∘ elimination* (including asymmetrical molecules) ∘ esterification ∘ combustion ∘ incomplete combustion • predict all possible products for those equations marked by an *
• define *monomer* and *polymer* • given a diagram of a polymer, identify the type of polymerization reaction that formed it (i.e. addition or condensation)	
• given a diagram of a simple monomer (e.g., ethene), draw the diagram of the addition polymer that would form or use a model to illustrate the molecule	• given the diagrams or IUPAC names of two monomers, draw the diagram of the condensation polymer they would form and use a model to illustrate the molecule

Chemistry 30 General Outcome C2 ***Students will*** **describe chemical reactions of organic compounds.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	**Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:**
• given a diagram of a simple addition polymer (e.g., polyethene), draw the diagram of the monomer that formed that polymer and use a model to illustrate the molecule • when given a balanced chemical equation for a reaction used to produce thermal energy or economically important compounds from fossil fuels, classify the reaction as ◦ combustion ◦ addition (e.g., hydrogenation to produce saturated compounds) ◦ elimination (e.g., to produce chloroethene for polymerization)	• given a diagram of a simple copolymer, draw diagrams and give the IUPAC names of the monomers that formed it • given the diagram of a condensation polymer, draw the diagrams or provide the IUPAC names of the monomers that formed it • given a diagram of a polymer, classify it as produced in living or nonliving systems
• when given a balanced chemical reaction, identify it as a cracking reaction or a reforming reaction	• explain why cracking and reforming reactions are important in the processing of fossil fuels • design an experiment to produce an ester, including a detailed procedure and a list of required materials (reagents and apparatus)
• identify manipulated, responding, and controlled variables given the analysis and procedure • when given the IUPAC name or diagram of an alcohol and a carboxylic acid, draw the structural diagram or provide the IUPAC name for the ester produced • interpret WHMIS symbols on laboratory reagents, and describe how to handle, store, and dispose of these materials • follow instructions and collect data using available equipment to investigate reactions of organic compounds • use print or electronic resources to collect information on organic compounds • use appropriate IUPAC guidelines when writing the names and formulas of organic compounds involved in reactions	• when given a statement of a hypothesis, identify the major variables and suitable reagents to test this hypothesis • suggest improvements to an experimental design
• identify methane, carbon dioxide, water, and nitrous oxide as greenhouse gases • describe the effect of greenhouse gases on climate change	• identify natural and human-influenced or human-caused sources of greenhouse gases • suggest methods that would reduce the production of greenhouse gases

Chemistry 30 General Outcome C2 ***Students will*** **describe chemical reactions of organic compounds.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	**Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:**
• when given simple data about greenhouse gases, analyze their contribution to climate change (e.g., when given the percentage of each gas, identify the gas responsible for the greatest contribution to climate change)	• when given complex data about greenhouse gases, analyze their contribution to climate change (e.g., atmospheric lifetime and global warming potential (GWP))
• work collaboratively in a group	• take a positive leadership role in group activities
• describe how organic processes, or the use of organic compounds, can have intended and unintended consequences for humans and the environment	• explain how organic processes, or the use of organic compounds, can have intended and unintended consequences for humans and the environment

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Chemistry 30 General Outcome D1 ***Students will*** **explain that there is a balance of opposing reactions in chemical equilibrium systems.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	**Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:**

• define a dynamic chemical equilibrium using the criteria that apply to a chemical system in equilibrium
  ∘ system closed to matter and energy
  ∘ constancy of properties (e.g., conductivity, colour, pressure, pH)
  ∘ equal rates of forward and reverse reactions
• interpret data from a graph to identify when equilibrium is established
	• explain how a dynamic chemical equilibrium can be established

• when given a graph of the concentrations of equilibrium components as a function of time, identify the reactants and products	• when given a graph of the concentrations of equilibrium components as a function of time, write the balanced chemical equation that represents the equilibrium

• when given a balanced equilibrium equation including energy, predict the direction of the shift when
  ∘ equilibrium components are added or removed
  ∘ temperature is increased or decreased
  ∘ pressure is increased or decreased by changing the volume
  ∘ an inert gas is added
  ∘ a catalyst is added
• state that temperature change is the only factor that can affect the value of the equilibrium constant
• when given a graph of the concentrations of equilibrium components as a function of time, identify stresses caused by the
  ∘ addition of components
  ∘ removal of components
  ∘ addition of a catalyst or an inert gas
• when given a balanced equation and the shift in equilibrium, predict qualitatively the change in concentration for the reaction components
• when given a balanced equilibrium equation, predict stresses that would cause a given shift in the equilibrium
	• when given a balanced equilibrium equation, predict the direction of the shift when equilibrium components are removed by precipitation or neutralization
	• when given an unbalanced or implied equilibrium equation, predict the direction of the shift when
	  ∘ components are added or removed
	  ∘ temperature is increased or decreased
	  ∘ pressure is increased or decreased by changing the volume
	• predict qualitatively how the value of the equilibrium constant will be changed (i.e., increase or decrease) when the equilibrium system is heated or cooled
	• when given a graph of the concentrations of equilibrium components as a function of time, identify stresses caused by
	  ∘ changes in volume
	  ∘ changes in temperature
	  ∘ the removal of equilibrium components by precipitation or neutralization
	• when given a balanced equilibrium equation, predict qualitative observations (e.g., colour, pH, conductivity, gas production) that would be made as a result of a shift in the equilibrium system

Chemistry 30 General Outcome D1 ***Students will*** **explain that there is a balance of opposing reactions in chemical equilibrium systems.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	**Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:**
• when given a balanced equation for a homogeneous equilibrium, write the equilibrium law expression using lowest whole number exponents • when given the equilibrium law expression, write the balanced equation that would represent that equilibrium	• when given a balanced equation for a heterogeneous equilibrium, write the equilibrium law expression using lowest whole number exponents
• when given a graph of the concentrations of equilibrium components as a function of time, write the equilibrium law expression that represents the equilibrium	• when given a graph of the concentrations of equilibrium components as a function of time, write the equilibrium law expression that represents the equilibrium • when given a graph of the concentrations of equilibrium components as a function of time, estimate the value of K_c (i.e., > 1, or < 1)
• when given the value of K_c, identify whether ∘ products or reactants are favoured ∘ products or reactants are present in greater quantity at equilibrium ∘ the extent of the forward reaction is greater than or less than 50% • define a Brønsted–Lowry acid as a proton donor and a Brønsted–Lowry base as a proton acceptor	• when given balanced equilibrium equations and the value of K_c, rank reactions based upon ∘ the extent of the reaction ∘ the amount of products or reactants present at equilibrium
• when given a net ionic equation of simple reactions (i.e., species found in the table of the Relative Strengths of Acids and Bases), identify the species acting as the acid or the base	• when given a net ionic equation of an unfamiliar reaction, identify the species acting as the acid or the base
• when given monoprotic species found in the table of the Relative Strengths of Acids and Bases, write the Brønsted–Lowry equation that represents the reaction that will occur including ∘ whether the reaction is quantitative ∘ whether reactants or products are favoured ∘ the extent of the reaction (i.e., > 50% or < 50%)	• when given a monoprotic species found in the table of the Relative Strengths of Acids and Bases and an unfamiliar species (with a K_a or K_b value given), write the Brønsted–Lowry equation that represents the reaction that will occur and predict ∘ whether reactants or products are favoured ∘ the extent of the reaction (i.e., > 50% or < 50%)

Chemistry 30 General Outcome D1 ***Students will*** **explain that there is a balance of opposing reactions in chemical equilibrium systems.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	**Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:**
• when given a net ionic equation involving a transfer of one proton between species found in the table of the Relative Strengths of Acids and Bases, predict ◦ whether the reaction is quantitative ◦ whether reactants or products are favoured ◦ the extent of the reaction (i.e., > 50% or < 50%)	• when given a polyprotic species and the number of equivalence points or information that the species reacts completely, write the net ionic equation that represents all the quantitative reactions that will occur
• predict the net ionic equation for the reaction between an indicator and a strong acid or strong base and describe the change in the colour of the solution	• predict the net ionic equation for the reaction between an indicator and a weak acid or weak base found in the table of the Relative Strengths of Acids and Bases
• when given a Brønsted–Lowry reaction, identify the conjugate acid-base pairs present • when given a species on the table of the Relative Strengths of Acids and Bases, predict the identity of its conjugate acid or conjugate base • when given the chemical formula, identify amphiprotic species	• when given an unfamiliar species, predict the identity of its conjugate acid or conjugate base
• define a buffer as relatively large amounts of a weak acid or base and its conjugate in an equilibrium that maintains a relatively constant pH when small amounts of a stronger acid or base are added	• describe in detail how to prepare a buffer solution
• when given a list of chemical species, identify the pair that can act as a buffer	• when given the chemical formula for a weak acid or weak base, predict the chemical formula for the species that would form a buffer with the given substance • design an experiment to show a shift in an equilibrium for a given equilibrium system that includes a detailed procedure and a list of required materials (reagents and apparatus)

Chemistry 30 General Outcome D1 ***Students will*** **explain that there is a balance of opposing reactions in chemical equilibrium systems.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	**Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:**
• identify manipulated, responding, and controlled variables given the analysis and procedure • plot experimental data given manipulated and responding variables, and insert a line of best fit that may be either straight or curved • predict variables what will cause a shift in equilibrium when given the equilibrium system, including energy • describe a simple experiment to show equilibrium shifts (e.g., colour change, temperature change, precipitation)	• when given a statement of a hypothesis, identify the major variables and suitable reagents to test this hypothesis • analyze a plot of experimental data and describe qualitatively the relationship between the variables based on the shape of the line of best fit • identify all observations (e.g., colour change, pH change, gas production, precipitation) that must be made in an equilibrium experiment • explicitly explain how experimental observations will be analyzed • suggest improvements to an experimental design to study shifts in equilibrium • interpret WHMIS symbols on laboratory reagents, and describe how to handle, store, and dispose of these materials
• follow instructions and collect data using available equipment to test, qualitatively, predictions of equilibrium shifts (e.g., colour change, temperature change, precipitation and gas production)	
• when given a titration curve, identify ◦ whether the sample is a weak acid or a weak base ◦ whether the titrant is a strong acid or strong base ◦ whether the sample is monoprotic or polyprotic ◦ the location of the equivalence point(s) ◦ the approximate pH of the equivalence point ◦ the buffering region(s) ◦ a suitable indicator for a given equivalence point • when given the net ionic equation, identify the titration curve that would represent that equation	• when given a titration curve, identify ◦ relative amounts of species at specified locations on the curve ◦ the net ionic equation that represents the reaction that is occurring in a region ◦ suitable indicators for a polyprotic titration ◦ the species responsible for the pH at the equivalence point ◦ the species responsible for buffering
• work collaboratively in a group	• take a positive leadership role in group activities

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Chemistry 30 General Outcome D1 ***Students will*** **explain that there is a balance of opposing reactions in chemical equilibrium systems.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:
• describe an equilibrium system observable in the natural world • describe how equilibrium concepts were developed through scientific investigation • describe an equilibrium process or technology that meets a need in society	• explain the role of an equilibrium in the natural world • explain how equilibrium concepts are applied to improve the efficiency of important chemical processes that meet a need in society

Chemistry 30 General Outcome D2 ***Students will*** **determine quantitative relationships in simple equilibrium systems.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:
• calculate the pH when given the $[H_3O^+(aq)]$, or pOH when given the $[OH^-(aq)]$ • calculate the pH when given the pOH or pOH when given the pH	• explain the difference in the calculation strategies when determining the pH or pOH of strong and weak acids or bases • when given the pOH of a solution, calculate the $[H_3O^+(aq)]$; when given the pH of a solution, calculate the $[OH^-(aq)]$
• when given the pH or pOH of a solution, identifiy the relative amounts of $[H_3O^+(aq)]$ and $[OH^-(aq)]$ • write the balanced equation together with the equilibrium law expression that represents the value of K_w and state that this value is equal to 1.0×10^{-14} at 25.00 °C (298.15 K) • when given an unbalanced equation, write the balanced equation together with the equilibrium law expression that represents the value of K_a or K_b • when given the value of K_a for a weak acid or the name of an acid in the table of the Relative Strengths of Acids and Bases, calculate the value of K_b for the conjugate base	• when given the pH or pOH values for two solutions, identify the relative amounts of $[H_3O^+(aq)]$ and $[OH^-(aq)]$ in the solutions
• when given the initial concentration of a weak acid in the table of the Relative Strengths of Acids and Bases, calculate the $[H_3O^+(aq)]$ at equilibrium	• when given the initial concentration of a weak acid in the table of the Relative Strengths of Acids and Bases, calculate the pH at equilibrium • when given the initial concentration of an unfamiliar weak acid and the value of its K_a, calculate the pH at equilibrium • when given the initial concentration of a weak base in the table of the Relative Strengths of Acids and Bases, calculate the $[OH^-aq)]$, pH, or pOH at equilibrium • when given the initial concentration of an unfamiliar weak base and the value of its K_b, calculate the $[OH^-(aq)]$, pH, or pOH at equilibrium

Chemistry 30 General Outcome D2 ***Students will*** **determine quantitative relationships in simple equilibrium systems.**

Behaviours of a student functioning at the *Acceptable Standard* include, but are not limited to, the following:	Behaviours of a student functioning at the *Standard of Excellence* include, but are not limited to, the following:
• when given the balanced equilibrium equation and equilibrium concentrations of all components, calculate the value of the equilibrium constant • when given the balanced equation, initial concentrations, and one equilibrium concentration, calculate the ∘ amount of change for a particular component ∘ the equilibrium concentration of a particular component • when given a simple balanced equation, the value of K_c and all but one equilibrium concentration, calculate the equilibrium concentration of the remaining component	• when given an unbalanced equilibrium equation and the equilibrium concentrations of all components, calculate the value of the equilibrium constant • when given an unbalanced equation, the value of K_c, and concentrations of all but one component, calculate the equilibrium concentration of that component • when an equation, initial concentrations, and one equilibrium concentration are given, calculate the value of the equilibrium constant • when given the balanced equation, the value of K_c and one equilibrium concentration, calculate the initial concentration of any other component
• when given a balanced equation and a graph of the concentrations of equilibrium components as a function of time, calculate the value of the equilibrium constant	• when given a graph of the concentrations of equilibrium components as a function of time, calculate the value of the equilibrium constant
• work collaboratively in a group	• take a positive leadership role in group activities
• express calculated answers with appropriate significant digits • rely on the use of algorithms and formulas to solve problems	• when collecting data, express measured values with appropriate significant digits • choose the most efficient way of solving problems, using general methods such as unit analysis
• describe a technological development in equilibrium chemistry that was discovered by refining prior knowledge in chemistry or other fields	• explain how our understanding of equilibrium chemistry has been enhanced by knowledge from related fields

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