CHEMISTRY 12

Big Ideas	Elaborations
Dynamic Equilibrium • Some chemical reactions are reversible and proceed to equilibrium. • Dynamic equilibrium can be altered by changing the surrounding conditions.	*Sample opportunities to support inquiry with students:* • What are the conditions that can affect equilibrium?
Solubility Equilibrium • Saturated solutions are systems in equilibrium.	*Sample opportunities to support inquiry with students:* • How is the solubility constant useful in studying chemical processes?
Acids and Bases • The strength of an acid or base depends on the degree of dissociation of its ions. • Weak acids, weak bases, and buffers are systems in equilibrium.	*Sample opportunities to support inquiry with students:* • How are the concepts of acid/base strength (i.e., strong versus weak) and acid/base concentration (i.e., concentrated versus dilute) different? • How can acid/base dissociation be measured? • How is the degree of dissociation useful in studying chemical processes? • How are acids and bases systems in equilibrium? • What are some applications of acid-base reactions?
Oxidation-Reduction • Reduction and oxidation are complementary processes that involve the gain or loss of electrons. • Redox reactions have implications for resource development and for the environment.	*Sample opportunities to support inquiry with students:* • How can electrochemical and electrolytic cells be used in practical situations? • What are some applications of redox reactions?
MODULE YOU MAY CHOOSE TO INCLUDE:	
Reaction Kinetics • Reactants must collide to react. • Conditions surrounding a reaction determine its rate.	*Sample opportunities to support inquiry with students:* What factors influence the way reactant molecules, atoms, and ions collide?

Curricular Competencies	Elaborations	Content	Elaborations

Students are expected to be able to do the following:
Questioning and predicting
• Demonstrate a sustained intellectual curiosity about a scientific topic or problem of personal, local, or global interest
• **Make observations aimed at identifying their own questions**, including increasingly abstract ones, about the natural world
• Formulate multiple hypotheses and predict multiple outcomes
 	
Planning and conducting
	Sample opportunities to support inquiry with students:
	Questioning and predicting
	Make observations aimed at identifying their own questions:
	Solubility Equilibrium
	• Predict qualitative changes in the solubility equilibrium on the addition of a common ion or the removal of an ion.
	
	Reaction Kinetics
	• Choose a property that can be monitored to determine a reaction rate.
		THIS COURSE COMPRISES FOUR MODULES AND ONE MODULE (REACTION KINETICS), WHICH TEACHERS MAY CHOOSE TO INCLUDE.
		
		Students are expected to know the following:
		Dynamic Equilibrium
		• **dynamic nature of chemical equilibrium**
		• equilibrium shifts:
		  o effect of enthalpy and entropy on equilibrium
		  o **application of Le Châtelier's principle**
		  o effect of a catalyst
		• **equilibrium constant, K_{eq}**
			Dynamic Equilibrium
			• **dynamic nature of chemical equilibrium:**
			  o reversible nature of reactions
			  o relationship to PE diagram
			  o effects of changing concentrations of reactants and products
			• **application of Le Châtelier's principle:**
			  o Haber process
			  o hemoglobin and oxygen in the blood
			• **equilibrium constant, K_{eq}:**
			  o homogeneous and heterogeneous systems
			  o pure solids and liquids
			  o effect of changes in temperature,

- Collaboratively and individually **plan, select, and use appropriate investigation methods**, including field work and lab experiments, to collect reliable data (qualitative and quantitative)
- Assess risks and address ethical, cultural, and/or environmental issues associated with their proposed methods
- Use appropriate SI units and appropriate equipment, including digital technologies, to systematically and accurately collect and record data
- Apply the concepts of accuracy and precision to experimental procedures and data:
  - significant figures
  - uncertainty
  - scientific notation

Processing and analyzing data and information

- Experience and interpret the local environment
- Apply **First Peoples perspectives** and knowledge, other ways of knowing, and local knowledge as sources of information
- Seek and analyze patterns, trends, and connections in data, including **describing relationships between variables**, **performing calculations**, and identifying inconsistencies
- **Construct, analyze, and interpret graphs, models, and/or diagrams**
- Use knowledge of scientific concepts to draw conclusions that are consistent with evidence
- Analyze cause-and-effect relationships

Evaluating

- Evaluate their methods and experimental conditions, including identifying sources of error or uncertainty, confounding variables, and possible alternative explanations and conclusions
- Describe specific ways to improve their investigation methods and the quality of the data

- Observe catalyzed reactions, such as:
  - decomposition of hydrogen peroxide (MnO_2, etc)
  - decomposition of bleach ($CoCl_2$)
  - autocatalysis of oxalate and $KMnO_4$ (Mn^{2+})

Planning and conducting

plan, select, and use appropriate investigation methods:

Dynamic Equilibrium

- Gather and interpret data on the concentration of reactants and products of a system at equilibrium.

Solubility Equilibrium

- Use a solubility chart to predict whether ions can be separated from solution through precipitation, and outline an experimental procedure that includes compound added, precipitate formed, and method of separation.
- Identify an unknown ion through experimentation involving a qualitative analysis scheme.
- Devise a procedure by which ions (e.g., calcium or magnesium) can be removed from hard water.
- Devise a method for determining the concentration of a specific ion by titration or gravimetric methods (e.g., concentration of chloride ion using a precipitation reaction with silver ion).

Acids and Bases

- Identify acids and bases through experimentation.
- Design, perform, and analyze a titration experiment involving:
  - primary standards
  - standardized solutions
  - titration curves
  - appropriate indicators

- **quantitative problem solving**:
  - to evaluate the changes in the value of Keq and in concentrations of substances
  - to determine if a system is at equilibrium and resultant shifts

Solubility Equilibrium

- saturated solutions as equilibrium systems
- equilibrium constant expression, Ksp, for a saturated solution
- **quantitative problem solving** involving solubility equilibrium concepts

Acids and Bases

- different types of acids and bases:
  - Arrhenius acids and bases
  - Brönsted-Lowry acids and bases
- **relative strength of acids and bases in solution**
- equilibrium in weak acid or weak base systems
- amphiprotic species
- equilibrium that exists in water and Kw
- calculate [H_3O^+] or [OH-] given the other, using Kw
- calculate [H3O+] or [OH-] from pH and pOH
- **quantitative problem solving** involving the acid-base equilibrium constants (Ka and Kb)
- **titration**
- write formulae, complete ionic equations, and net ionic equations for strong and weak acids and bases
- quantitative calculations involving titration, including concentration, volume, and pH
- **indicators**
- quantitative calculations involving the pH in a solution and Ka for an indicator
- applications of acid/base reactions
- **hydrolysis of ions in salt solutions**
- calculation of the pH of a salt solution from relevant data, assuming that the predominant hydrolysis reaction is the only reaction determining the pH

pressure, concentration, surface area, and a catalyst

- **quantitative problem solving:**
  - involving the value of Keq and the equilibrium concentration of all species
  - involving the value of Keq and the initial concentrations of all species, and one equilibrium
  - involving the equilibrium concentrations of all species, the value of Keq, and the initial concentrations

Solubility Equilibrium

quantitative problem solving:

- solubility product, Ksp, for a compound when given its solubility
- the solubility of a compound from its Ksp
- predicting the formation of a precipitate by comparing the trial ion product to the Ksp value using specific data
- the maximum allowable concentration of one ion given the Ksp and the concentration of the other ion just before precipitation occurs

Acids and Bases

- **relative strength of acids and bases in solution:**
  - electrical conductivity
  - table of relative acid strength
  - equations of strong and weak acids and bases in water
- **quantitative problem solving:**
  - Given the Ka, Kb, and initial concentration, calculate any of the following: [H_3O+], [OH-], pH, pOH.
  - Calculate the value of Kb for a base, given the value of Ka for its conjugate acid (or vice versa).
  - Calculate the value of Ka or Kb, given the pH and initial concentration.
  - Calculate the initial concentration of an

• Evaluate the validity and limitations of a model or analogy in relation to the phenomenon modelled • Demonstrate an awareness of assumptions, question information given, and identify bias in their own work and in primary and secondary sources • Consider the changes in knowledge over time as tools and technologies have developed • Connect scientific explorations to careers in science • Exercise a healthy, informed skepticism and use scientific knowledge and findings to form their own investigations to evaluate claims in primary and secondary sources • Consider social, ethical, and environmental implications of the findings from their own and others’ investigations • Critically analyze the validity of information in primary and secondary sources and evaluate the approaches used to solve problems • Assess risks in the context of personal safety and social responsibility Applying and innovating • Contribute to care for self, others, community, and world through individual or collaborative approaches • Co-operatively design projects with local and/or global connections and applications • Contribute to finding solutions to problems at a local and/or global level through inquiry • Implement multiple strategies to solve problems in real-life, applied, and conceptual situations • Consider the role of scientists in innovation Communicating • Formulate physical or mental theoretical models to describe a phenomenon	o proper technique • Match an indicator’s colour in a solution with an approximate pH, using a table of indicators. • Prepare a buffer system. Oxidation-Reduction • From data for a series of simple redox reactions, create a simple table of reduction half-reactions. • Determine the concentration of a species by performing a redox titration: o Demonstrate familiarity with at least two common reagents used in redox titrations (e.g., permanganate, dichromate, hydrogen peroxide). o Select a suitable reagent to be used in a redox titration, in order to determine the concentration of a species. • Identify reactants and products for various redox reactions performed in a laboratory, and write balanced equations. • Construct an electrochemical cell, determine the half-reactions that take place at each electrode of an electrochemical cell, and use these to make predictions about the overall reaction with regard to movement of ions in the cells and in the circuit, and the resulting mass of the electrodes. • Design and label the parts of an electrolytic cell: o used for the electrolysis of a molten binary salt such as $NaCl_{(l)}$ o capable of electrolyzing an aqueous salt such as $KI_{(aq)}$ (use of overpotential effect not required) o electroplating an object Reaction Kinetics • Determine the rate of a reaction through experiment. Processing and analyzing data and information **First Peoples perspectives:**	• **buffers as equilibrium systems** • oxides in water • general environmental problems associated with non-metal oxides reacting with water Oxidation-Reduction • **the oxidation-reduction process** • **relative strength of oxidizing and reducing agents** • balancing redox reactions • redox titration • quantitative problem solving involving the concentration of a species in a redox titration from data (e.g., grams, moles, molarity) • electrochemical cells: o half-reactions o cell voltage (E^0) o **practical applications** • electrolytic cells: o half-reactions o minimum voltage to operate o **practical applications** MODULE YOU MAY CHOOSE TO INCLUDE: Reaction Kinetics • **reaction rate** • factors that affect reaction rates • **collision theory**: o collision geometry o kinetic energy • relate PE, KE, and enthalpy (ΔH) during a reaction • chemical equations describing energy effects • **reaction mechanism** • effect of a catalyst on a PE diagram • **applications of catalysts**	acid or base, given the appropriate Ka, Kb, pH, or pOH values. • **titration:** o equivalence point (stoichiometric point) of a strong acid–strong base titration o equivalence point of a titration involving a weak acid–strong base or strong acid–weak base Oxidation-Reduction • **indicators:** o indicators chosen so endpoint coincides with the equivalence point of a titration reaction o a mixture of a weak acid and its conjugate base, each with distinguishing colours o transition point o equilibrium shift as acid or base is added during a titration • **hydrolysis of ions in salt solutions:** o A salt solution can be acidic, basic, or neutral (compare Ka and Kb values). o An amphiprotic ion can act as a base or an acid in solution (compare Ka and Kb values). • **buffers as equilibrium systems:** o The buffer equilibrium shifts as small quantities of acid or base are added to the buffer. o a common buffer system (e.g., the blood buffer system) o limits to buffer systems • **the oxidation-reduction process:** o oxidation (loss of electrons) o reduction (gain of electrons) o oxidation number • **relative strength of oxidizing and reducing agents:** The “Standard Reduction Potentials of Half-Cells” table can be used to predict whether a spontaneous redox reaction will occur between any two species. • **practical applications:**

• Communicate scientific ideas, information, and perhaps a suggested course of action, for a specific purpose and audience, constructing evidence-based arguments and using appropriate scientific language, conventions, and representations
• Express and reflect on a variety of experiences, perspectives, and worldviews through place
	• Research the types of materials that are present in clay deposits traditionally used to treat skin conditions.
	
	describing relationships between variables:
	Dynamic Equilibrium
	• Predict, with reference to entropy and enthalpy, whether reacting systems will reach equilibrium when:
	    o both favour products
	    o both favour reactants
	    o entropy and enthalpy oppose each other
	• Relate the equilibrium position to the value of Keq.
	
	Reaction Kinetics
	• Compare and contrast factors affecting the rates of both homogeneous and heterogeneous reactions.
	• Relate the magnitude of the activation energy to the rate of the reaction.
	
	performing calculations:
	Dynamic Equilibrium
	• quantitative problem solving involving K_{eq}
	
	Solubility Equilibrium
	• calculations involving concentration of ions
	• calculations involving solubility equilibrium concepts
	
	Acids and Bases
	• quantitative calculations involving:
	    o pH, pOH, [H_3O+], and [OH-]
	    o the ionization constant of water (Kw)
	    o the acid-base equilibrium constants (Ka and Kb)
	    o titration
	    o indicator
	    o hydrolysis
			o lead-acid storage batteries, alkali cells, hydrogen-oxygen fuel cells
			• **practical applications:**
			    o metal refining (e.g., zinc, aluminum)
			    o preventing metal corrosion (e.g., cathodic protection)
			
			Reaction Kinetics
			• **reaction rate:**
			    o a quantity produced or consumed over time (negative and positive rates)
			    o heterogeneous and homogeneous reactions
			    o applications/situations when rate must be controlled
			• **collision theory:**
			    o relationship between successful collisions and reaction rate
			    o relationship of activated complex, reaction intermediates, and activation energy to PE diagrams
			• **reaction mechanism:**
			    o relate the overall reaction to a series of steps (collisions)
			    o rate-determining step
			• **applications of catalysts:**
			    o platinum in automobile catalytic converters
			    o catalysis in the body
			    o contribution of chlorine from CFCs to ozone depletion

	Oxidation-Reduction • quantitative calculations involving a redox titration • Calculate the voltage (E^0) of an electrochemical cell. Reaction Kinetics • Calculate the rate of a reaction using experimental data. **Construct, analyze, and interpret graphs, models, and/or diagrams:** Dynamic Equilibrium • Illustrate how the reversible nature of most chemical reactions can be represented on a PE diagram. Acids and Bases • Interpret titration curves plotted from experimental data. Reaction Kinetics • Draw and label PE diagrams for both exothermic and endothermic reactions, including ΔH, activation energy, and the energy of the activated complex. • Use a KE distribution curve to explain how changing the temperature or adding a catalyst changes the rate of a reaction. • Analyze PE diagrams for exothermic and endothermic reactions, catalyzed and uncatalyzed reactions.		