Student Name: ______________________ Date: _____________________

Chemistry 40S

Course Outcomes
Gases and the Atmosphere

Learning Outcomes:

- ❑ Identify the abundances of the naturally occurring gases in the atmosphere and examine how these abundances have changed over geologic time.

  Include: oxygenation of Earth's atmosphere, the role of biota in oxygenation, changes in carbon dioxide content over time

- ❑ Research Canadian and global initiatives to improve air quality.
- ❑ Examine the historical development of the measurement of pressure.

  Examples: the contributions of Galileo Galilei, Evangelista Torricelli, Otto von Guericke, Blaise Pascal, Christiaan Huygens, John Dalton, Joseph Louis Gay-Lussac, Amadeo Avogadro…

- ❑ Describe the various units used to measure pressure.

  Include: atmospheres (atm), kilopascals (kPa), millimetres of mercury (mmHg), millibars (mb)

- ❑ Experiment to develop the relationship between the pressure and volume of a gas using visual, numeric, and graphical representations.

  Include: historical contributions of Robert Boyle

- ❑ Experiment to develop the relationship between the volume and temperature of a gas using visual, numeric, and graphical representations.

  Include: historical contributions of Jacques Charles, the determination of absolute zero, the Kelvin temperature scale

- ❑ Experiment to develop the relationship between the pressure and temperature of a gas using visual, numeric, and graphical representations.

  Include: historical contributions of Joseph Louis Gay-Lussac

- ❑ Solve quantitative problems involving the relationships among the pressure, temperature, and volume of a gas using dimensional analysis.

  Include: symbolic relationships

- ❑ Identify various industrial, environmental, and recreational applications of gases.

  Examples: self-contained underwater breathing apparatus (scuba), anaesthetics, air bags, acetylene welding, propane appliances, hyperbaric chambers…

Labs:

- ❑ Boyle’s Law
- ❑ Cartesian Diver
- ❑ The Density of Carbon Dioxide

Chemistry 40S

Course Outcomes
Aqueous Reactions

Learning Outcomes:

- ❑ Explain examples of solubility and precipitation at the particulate and symbolic levels.
- ❑ Perform a lab to develop a set of solubility rules.
- ❑ Use a table of solubility rules to predict the formation of a precipitate.
- ❑ Write balanced neutralization reactions involving strong acids and bases.
- ❑ Perform a lab to demonstrate the stoichiometry of a neutralization reaction between a strong base and a strong acid.
- ❑ Calculate the concentration or volume of an acid or base from the concentration and volume of an acid or base required for neutralization.
- ❑ Design and implement a procedure to determine the identity of a number of unknown solutions.
- ❑ Outline the development of our understanding of oxidation and reduction reactions.

  Include: gain or loss of oxygen, loss or gain of electrons
- ❑ Determine the oxidation numbers for atoms in compounds and ions.
- ❑ Identify reactions as redox or non redox.

  Include: oxidizing agent, reducing agent, substance oxidized and substance reduced
- ❑ Balance oxidation-reduction reactions using redox methods.
- ❑ Research practical applications of redox reactions.

  Examples: rocket fuels, fireworks, household bleach, photography, metal recovery from ores, steel making, aluminum recycling, fuel cells, batteries, tarnish removal, fruit clocks, forensic blood detection using luminal, corrosion glass, chemiluminescence/bioluminescence, electrolytic cleaning, electrodeposition, photochemical etching, antioxidants/preservatives

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LABS:

- ❑ Developing a Set of Solubility Rules

Chemistry 40S

Course Outcomes
Atomic Structure

Learning Outcomes:

- ❑ Qualitatively describe the electromagnetic spectrum in terms of frequency, wavelength, and energy.
- ❑ Recognize, through direct observation, that elements have unique line spectra
- ❑ Include: flame tests or gas discharge tubes, spectroscopes or diffraction gratings.
- ❑ Describe applications and/or natural occurrences of line spectra.

  Examples: astronomy, aurora borealis, fireworks, neon lights.
- ❑ Outline the historical development of the Quantum Mechanical Model of the atom.
- ❑ Write electron configurations for elements of the periodic table.

  Include: selected elements up to atomic number 36 (Krypton)
- ❑ Relate the electron configuration of an element to its valence electron(s) and its position on the periodic table.
- ❑ Identify and account for periodic trends among the properties of elements, and relate to electron configuration.

  Include: atomic radii, ionic radii, ionization energy, electronegativity

Labs:

- ❑ Flame Test
- ❑ Emission and Absorption Spectra

Student Name: ______________________ Date: _____________________

Chemistry 40S

Course Outcomes

Kinetics

Learning Outcomes:

- ❑ Formulate an operational definition of reaction rate.

  Include: examples of chemical reactions that occur at different rates.
- ❑ Identify variables used to monitor reaction rates (i.e. change per unit time, $\Delta x/\Delta t$).

  Examples: pressure, temperature, pH, conductivity, color.
- ❑ Perform a lab to measure the average and instantaneous rate of a chemical reaction.

  Include: initial rate
- ❑ Relate the rate of formation of a product to the rate of disappearance of a reactant given experimental rate data and reaction stoichiometry.

  Include: Descriptive treatment at the particulate level
- ❑ Perform a lab to identify factors that affect the rate of a chemical reaction.

  Include: nature of reactants, surface area, concentration, pressure, volume, temperature, and presence of a catalyst.
- ❑ Use the collision theory to explain the rate of chemical reactions.

  Include: Activation energy
- ❑ Draw potential energy diagrams for endothermic and exothermic reactions.

  Include: relative rates, effect of a catalyst, heat of reaction (enthalpy change)
- ❑ Describe qualitatively the relationship between factors which affect the rate of chemical reactions and the relative rate of a reaction using the Collision Theory.
- ❑ Explain the concept of a reaction mechanism.

  Include: rate determining step
- ❑ Determine the rate law and order of a chemical reaction from experimental data.

  Include: reactions that are zero, first or second order, rate versus concentration graphs.

Labs:

- ❑ Factors Affecting Reaction Rate

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Chemistry 40S

Course Outcomes
Equilibrium

Learning Outcomes:

- ❑ Relate the concept of equilibrium to physical and chemical systems.

  Include: conditions necessary to achieve equilibrium.

- ❑ Write equilibrium law expressions from balanced chemical equations for heterogeneous and homogeneous systems.

  Include: mass action expression.

- ❑ Use the value of the equilibrium constant to explain how far a system at equilibrium has gone towards completion.

- ❑ Solve problems involving equilibrium constants.

- ❑ Perform a lab to determine the equilibrium constant of an equilibrium system.

- ❑ Use Le Chatelier's principle to predict and explain shifts in equilibrium.

  Include: temperature changes, pressure/volume changes, changes in reactant/product concentration, the addition of a catalyst, the addition of an inert gas, the effects of various stresses on the equilibrium constant.

- ❑ Perform a lab to demonstrate Le Chatelier's principle.

- ❑ Interpret concentration versus time graphs.

  Include: temperature changes, concentration changes, addition of a catalyst.

- ❑ Describe practical applications of Le Chatelier's principle.

  Examples: Haber Process, haemoglobin production at high altitude, carbonated beverages, eyes adjusting to light, blood pH, recharging of batteries, turbocharged/supercharged engines, ester synthesis, weather indicators, arrangement of produce, carbonated beverages in a hen's diet.

- ❑ Write solubility product (K_{sp}) expressions from balanced chemical equations for salts with low solubility.

- ❑ Solve problems involving K_{sp}.

Include: common ion problems.

- ❑ Describe examples of salts with low solubilities.

  Examples: kidney stones, limestone caverns, osteoporosis, tooth decay.

- ❑ Perform a lab to determine the K_{sp} of a salt with low solubility.

Labs:

- ❑ Observe Shifts in Equilibrium
- ❑ Compare Two Solubility Product Constants

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Chemistry 40S

Course Outcomes
Solutions

Learning Outcomes:

- ❑ Describe and give examples of various types of solutions.

  Include: all nine possible types
- ❑ Describe the structure of water in terms of electronegativity and the polarity of its chemical bonds.
- ❑ Explain the solution process of simple ionic and covalent compounds, using visual, particulate representations and chemical equations.

  Include: crystal structure, dissociation, hydration
- ❑ Explain heat of solution with reference to specific applications.

  Examples: cold packs, hot packs…
- ❑ Perform a lab to illustrate the formation of solutions in terms of the polar and nonpolar nature of substances.

  Include: soluble, insoluble, miscible, immiscible
- ❑ Construct, from experimental data, a solubility curve of a pure substance in water.
- ❑ Differentiate among saturated, unsaturated, and supersaturated solutions.
- ❑ Use a graph of solubility data to solve problems.
- ❑ Explain how a change in temperature affects the solubility of gases.
- ❑ Explain how a change in pressure affects the solubility of gases.
- ❑ Perform a lab to demonstrate freezing-point depression and boiling-point elevation.
- ❑ Explain freezing-point depression and boiling-point elevation at the molecular level.

  Examples: antifreeze, road salt…

- ❑ Differentiate among, and give examples of, the use of various representations of concentration.

  Include: grams per litre (g/L), % weight-weight (% w/w), % weight-volume (% w/v), % volume/volume (% v/v), parts per million (ppm), parts per billion (ppb), moles per litre (mol/L) (molarity)
- ❑ Solve problems involving calculation for concentration, moles, mass, and volume.
- ❑ Prepare a solution, given the amount of solute (in grams) and the volume of solution (in millilitres), and determine the concentration in moles/litre.
- ❑ Solve problems involving the dilution of solutions.

  Include: dilution of stock solutions, mixing common solutions with different volumes and concentrations
- ❑ Perform a dilution from a solution of known concentration.
- ❑ Describe examples of situations where solutions of known concentration are important.

  Examples: pharmaceutical preparations, administration of drugs, aquaria, swimming-pool disinfectants, gas mixes for scuba, radiator antifreeze…
- ❑ Describe the process of treating a water supply, identifying the allowable concentrations of metallic and organic species in water suitable for consumption.

Labs:

- ❑ Saturated, Unsaturated and Supersaturated Solutions
- ❑ Concentrations and Dilutions
- ❑ Freezing Point Depression

Student Name: ______________________	Date: ______________________

Chemistry 40S

Course Outcomes
Acids and Bases

Learning Outcomes:

- ❑ Outline the historical development of acid base theories.

  Include: Arrhenius, Bronsted-Lowry, Lewis.
- ❑ Write balanced acid/base chemical equations.

  Include: conjugate acid/base pairs, amphoteric behavior.
- ❑ Describe the relationship between the hydronium and hydroxide ion concentrations in water

  Include: the ion product of water, K_w.
- ❑ Perform an activity to formulate an operational definition of pH.
- ❑ Describe how an acid-base indicator works in terms of colour shifts and Le Chatelier's Principle.
- ❑ Solve problems involving pH.
- ❑ Distinguish between strong and weak acids and bases.

  Include: electrolytes and non-electrolytes,
- ❑ Write the equilibrium expression (K_a or K_b) from a balanced chemical equation.
- ❑ Use K_a or K_b to solve problems for pH, percent dissociation and concentration.
- ❑ Using a standardized acid or base, determine the concentration of an unknown base or acid.
- ❑ Predict whether an aqueous solution of a given ionic compound will be acidic, basic or neutral given the formula.

Labs:

- ❑ Acid – Base Indicators and pH
- ❑ Determine the Percent Acetic Acid in Vinegar

Student Name: ______________________ Date: ______________________

Chemistry 40S Course Outcomes
Electrochemistry

Learning Outcomes:

- ❑ Develop an activity series experimentally.
- ❑ Predict the spontaneity of reactions using an activity series.
- ❑ Outline the historical development of voltaic (galvanic) cells.

  Include: contributions of Alessandro Volta, Luigi Galvani
- ❑ Explain the operation of a voltaic (galvanic) cell at the visual, particulate and symbolic levels.

  Include: writing half-cell reactions and overall reaction
- ❑ Construct a functioning voltaic (galvanic) cell and measure its potential.
- ❑ Define standard electrode potential.

  Include: hydrogen electrode as a reference
- ❑ Calculate standard cell potentials given standard electrode potentials.
- ❑ Predict the spontaneity of reactions using standard electrode potentials.
- ❑ Compare and contrast voltaic (galvanic) and electrolytic cells.
- ❑ Explain the operation of an electrolytic cell at the visual, particulate and symbolic levels.

  Include: a molten ionic compound; an aqueous ionic compound;
- ❑ Describe practical uses of electrolytic cells.

  Examples: electrolysis of water, electrolysis of brine, electroplating, production and purification of metals.
- ❑ Using Faraday's law, solve problems related to electrolytic cells.

Labs:

- ❑ Constructing a Voltaic Cell

Student Name: ____________________ Date: ____________________

Chemistry 40S

Course Outcomes

Gases and the Atmosphere

Learning Outcomes:

- ❑ Identify the abundances of the naturally occurring gases in the atmosphere and examine how these abundances have changed over geologic time.

  Include: oxygenation of Earth's atmosphere, the role of biota in oxygenation, changes in carbon dioxide content over time

- ❑ Research Canadian and global initiatives to improve air quality.
- ❑ Examine the historical development of the measurement of pressure.

  Examples: the contributions of Galileo Galilei, Evangelista Torricelli, Otto von Guericke, Blaise Pascal, Christiaan Huygens, John Dalton, Joseph Louis Gay-Lussac, Amadeo Avogadro…

- ❑ Describe the various units used to measure pressure.

  Include: atmospheres (atm), kilopascals (kPa), millimetres of mercury (mmHg), millibars (mb)

- ❑ Experiment to develop the relationship between the pressure and volume of a gas using visual, numeric, and graphical representations.

  Include: historical contributions of Robert Boyle

- ❑ Experiment to develop the relationship between the volume and temperature of a gas using visual, numeric, and graphical representations.

  Include: historical contributions of Jacques Charles, the determination of absolute zero, the Kelvin temperature scale

- ❑ Experiment to develop the relationship between the pressure and temperature of a gas using visual, numeric, and graphical representations.

  Include: historical contributions of Joseph Louis Gay-Lussac

- ❑ Solve quantitative problems involving the relationships among the pressure, temperature, and volume of a gas using dimensional analysis.

  Include: symbolic relationships

- ❑ Identify various industrial, environmental, and recreational applications of gases.

  Examples: self-contained underwater breathing apparatus (scuba), anaesthetics, air bags, acetylene welding, propane appliances, hyperbaric chambers…

Labs:

- ❑ Boyle’s Law
- ❑ Cartesian Diver
- ❑ The Density of Carbon Dioxide