Grade 12 Chemistry University: Organic Chemistry

Overall Expectations **OCV.01** · demonstrate an understanding of the structure of various organic compounds, and of chemical reactions involving these compounds; **OCV.02** · investigate various organic compounds through research and experimentation, predict the products of organic reactions, and name and represent the structures of organic compounds using the IUPAC system and molecular models; **OCV.03** · evaluate the impact of organic compounds on our standard of living and the environment.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*Number of times*
Understanding Basic Concepts										
OC1.01 – distinguish among the different classes of organic compounds, including alcohols, aldehydes, ketones, carboxylic acids, esters, ethers, amines, and amides, by name and by structural formula;										
OC1.02 – describe some physical properties of the classes of organic compounds in terms of solubility in different solvents, molecular polarity, odour, and melting and boiling points;										
OC1.03 – describe different types of organic reactions, such as substitution, addition, elimination, oxidation, esterification, and hydrolysis;										
OC1.04 – demonstrate an understanding of the processes of addition and condensation polymerization;										
OC1.05 – describe a variety of organic compounds present in living organisms, and explain their importance to those organisms (e.g., proteins, carbohydrates, fats, nucleic acids)										
Developing Skills of Inquiry and Communication										
OC2.01 – use appropriate scientific vocabulary to communicate ideas related to organic chemistry (e.g., *functional group, polymer*);										
OC2.02 – use the IUPAC system to name and write appropriate structures for the different classes of organic compounds, including alcohols, aldehydes, ketones, carboxylic acids, esters, ethers, amines, amides, and simple aromatic compounds;										
OC2.03 – build molecular models of a variety of aliphatic, cyclic, and aromatic organic compounds;										
OC2.04 – identify some nonsystematic names for organic compounds (e.g., *acetone, isopropyl alcohol, acetic acid*);										
OC2.05 – predict and correctly name the products of organic reactions, including substitution, addition, elimination, esterification, hydrolysis, oxidation, and polymerization reactions (e.g., preparation of an ester, oxidation of alcohols with permanganate);										
OC2.06 – carry out laboratory procedures to synthesize organic compounds (e.g., preparation of an ester, polymerization).										
Relating Science to Technology, Society, and the Environment										
OC3.01 – present informed opinions on the validity of the use of the terms organic, natural, and chemical in the promotion of consumer goods;										
OC3.02 – describe the variety and importance of organic compounds in our lives (e.g., plastics, synthetic fibres, pharmaceutical products);										
OC3.03 – analyse the risks and benefits of the development and application of synthetic products (e.g., polystyrene, aspartame, pesticides, solvents);										
OC3.04 – provide examples of the use of organic chemistry to improve technical solutions to existing or newly identified health, safety, and environmental problems (e.g., leaded versus unleaded gasoline; hydrocarbon propellants versus chlorofluorocarbons [CFCs]).										
Number of clustered expectations										

Grade 12 Chemistry University: Energy Changes and Rates of Reaction

Overall Expectations **ECV.01** · demonstrate an understanding of the energy transformations and kinetics of chemical changes; **ECV.02** · determine energy changes for physical and chemical processes and rates of reaction, using experimental data and calculations; **ECV.03** · demonstrate an understanding of the dependence of chemical technologies and processes on the energetics of chemical reactions.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*Number of times*
Understanding Basic Concepts										
EC1.01 – compare the energy changes resulting from physical change, chemical reactions, and nuclear reactions (fission and fusion);										
EC1.02 – explain Hess's law, using examples;										
EC1.03 – describe, with the aid of a graph, the rate of reaction as a function of the change of concentration of a reactant or product with respect to time; express the rate of reaction as a rate law equation (first- or second-order reactions only); and explain the concept of half-life for a reaction;										
EC1.04 – explain, using collision theory and potential energy diagrams, how factors such as temperature, surface area, nature of reactants, catalysts, and concentration control the rate of chemical reactions;										
EC1.05 – analyse simple potential energy diagrams of chemical reactions (e.g., potential energy diagrams showing the relative energies of reactants, products, and activated complex);										
EC1.06 – demonstrate understanding that most reactions occur as a series of elementary steps in a reaction mechanism.										
Developing Skills of Inquiry and Communication										
EC2.01 – use appropriate scientific vocabulary to communicate ideas related to the energetics of chemical reactions (e.g., *enthalpy, activated complex*);										
EC2.02 – write thermochemical equations, expressing the energy change as an ΔH value or as a heat term in the equation;										
EC2.03 – determine heat of reaction using a calorimeter, and use the data obtained to calculate the enthalpy change for a reaction (e.g., neutralization of sodium hydroxide and hydrochloric acid);										
EC2.04 – apply Hess's law to solve problems, including problems that involve data obtained through experimentation (e.g., measure heats of reaction that can be combined to yield the ΔH of combustion of magnesium);										
EC2.05 – calculate heat of reaction using tabulated enthalpies of formation;										
EC2.06 – determine through experimentation a rate of reaction (e.g., of hydrogen peroxide decomposition), and measure the effect on it of temperature, concentration, and catalysis.										
Relating Science to Technology, Society, and the Environment										
EC3.01 – compare conventional and alternative sources of energy with respect to efficiency and environmental impact (e.g., burning fossil fuels, solar energy, nuclear fission);										
EC3.02 – describe examples of technologies that depend on exothermic or endothermic changes (e.g., hydrogen rocket fuel, hot and cold packs);										
EC3.03 – describe the use of catalysts in industry (e.g., catalytic converters) and in biochemical systems (e.g., enzymes) on the basis of information gathered from print and electronic sources;										
EC3.04 – describe examples of slow chemical reactions (e.g., rusting), rapid reactions (e.g., explosions), and reactions whose rates can be controlled (e.g., food decay, catalytic decomposition of automobile exhaust).										
Number of clustered expectations										

Grade 12 Chemistry University: Chemical Systems and Equilibrium

Overall Expectations **CSV.01** · demonstrate an understanding of the concept of chemical equilibrium, Le Châtelier's principle, and solution equilibria; **CSV.02** · investigate the behaviour of different equilibrium systems, and solve problems involving the law of chemical equilibrium; **CSV.03** · explain the importance of chemical equilibrium in various systems, including ecological, biological, and technological systems.	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***Number of times***
Understanding Basic Concepts										
CS1.01 – illustrate the concept of dynamic equilibrium with reference to systems such as liquid-vapour equilibrium, weak electrolytes in solution, and chemical reactions;										
CS1.02 – demonstrate an understanding of the law of chemical equilibrium as it applies to the concentrations of the reactants and products at equilibrium;										
CS1.03 – demonstrate an understanding of how Le Châtelier's principle can predict the direction in which a system at equilibrium will shift when volume, pressure, concentration, or temperature is changed;										
CS1.04 – identify, in qualitative terms, entropy changes associated with chemical and physical processes;										
CS1.05 – describe the tendency of reactions to achieve minimum energy and maximum entropy;										
CS1.06 – describe, using the concept of equilibrium, the behaviour of ionic solutes in solutions that are unsaturated, saturated, and supersaturated;										
CS1.07 – define constant expressions, such as K_{sp}, K_w, K_a, and K_b;										
CS1.08 – compare strong and weak acids and bases using the concept of equilibrium;										
CS1.09 – describe the characteristics and components of a buffer solution.										
Developing Skills of Inquiry and Communication										
CS2.01 – use appropriate vocabulary to communicate ideas, procedures, and results related to chemical systems and equilibrium (e.g., *homogeneous, common ion, K_a value*);										
CS2.02 – apply Le Châtelier's principle to predict how various factors affect a chemical system at equilibrium, and confirm their predictions through experimentation;										
CS2.03 – carry out experiments to determine equilibrium constants (e.g., K_{eq} for iron [III] thiocyanate, K_{sp} for calcium hydroxide, K_a for acetic acid);										
CS2.04 – calculate the molar solubility of a pure substance in water or in a solution of a common ion, given the solubility product constant (K_{sp}), and vice versa;										
CS2.05 – predict the formation of precipitates by using the solubility product constant;										
CS2.06 – solve equilibrium problems involving concentrations of reactants and products and the following quantities: K_{eq}, K_{sp}, K_a, K_b, pH, pOH;										
CS2.07 – predict, in qualitative terms, whether a solution of a specific salt will be acidic, basic, or neutral;										
CS2.08 – solve problems involving acid-base titration data and the pH at the equivalence point.										
Relating Science to Technology, Society, and the Environment										
CS3.01 – explain how equilibrium principles may be applied to optimize the production of industrial chemicals (e.g., production of sulfuric acid, ammonia);										
CS3.02 – identify effects of solubility on biological systems (e.g., kidney stones, dissolved gases in the circulatory system of divers, the use of barium sulfate in medical diagnosis);										
CS3.03 – explain how buffering action affects our daily lives, using examples (e.g., the components in blood that help it to maintain a constant pH level; buffered medications).										
Number of clustered expectations										

Grade 12 Chemistry University: Electrochemistry

Overall Expectations **ELV.01** · demonstrate an understanding of fundamental concepts related to oxidation-reduction and the interconversion of chemical and electrical energy; **ELV.02** · build and explain the functioning of simple galvanic and electrolytic cells; use equations to describe these cells; and solve quantitative problems related to electrolysis; **ELV.03** · describe some uses of batteries and fuel cells; explain the importance of electrochemical technology to the production and protection of metals; and assess environmental and safety issues associated with these technologies.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*Number of times*
Understanding Basic Concepts										
EL1.01 – demonstrate an understanding of oxidation and reduction in terms of the loss and the gain of electrons or change in oxidation number;										
EL1.02 – identify and describe the functioning of the components in galvanic and electrolytic cells;										
EL1.03 – describe electrochemical cells in terms of oxidation and reduction half-cells whose voltages can be used to determine overall cell potential;										
EL1.04 – describe the function of the hydrogen half-cell as a reference in assigning reduction potential values;										
EL1.05 – demonstrate an understanding of the interrelationship of time, current, and the amount of substance produced or consumed in an electrolytic process (Faraday's law);										
EL1.06 – explain corrosion as an electrochemical process, and describe corrosion-inhibiting techniques (e.g., painting, galvanizing, cathodic protection).										
Developing Skills of Inquiry and Communication										
EL2.01 – use appropriate scientific vocabulary to communicate ideas related to electrochemistry (e.g., *half-reaction, electrochemical cell, reducing agent, redox reaction, oxidation number*);										
EL2.02 – demonstrate oxidation-reduction reactions through experiments, and analyse these reactions (e.g., compare the reactivity of some metals by arranging them in order of their ease of oxidation, which can be determined through observation of their ability to displace other metals from compounds; investigate the reactivity of oxidizing agents such as oxygen and various acids);										
EL2.03 – write balanced chemical equations for oxidation-reduction systems, including half-cell reactions;										
EL2.04 – determine oxidation and reduction half-cell reactions, direction of current flow, electrode polarity, cell potential, and ion movement in typical galvanic and electrolytic cells, including those assembled in the laboratory;										
EL2.05 – predict the spontaneity of redox reactions and overall cell potentials by studying a table of half-cell reduction potentials;										
EL2.06 – solve problems based on Faraday's law;										
EL2.07 – measure through experimentation the mass of metal deposited by electroplating (e.g., copper from copper II sulfate), and apply Faraday's law to relate the mass of metal deposited to the amount of charge passed**.**										
Relating Science to Technology, Society, and the Environment										
EL3.01 – describe examples of common galvanic cells (e.g., lead-acid, nickel-cadmium) and evaluate their environmental and social impact (e.g., describe how advances in the hydrogen fuel cell have facilitated the introduction of electric cars);										
EL3.02 – explain how electrolytic processes are involved in industrial processes (e.g., refining of metals, production of chlorine);										
EL3.03 – research and assess environmental, health, and safety issues involving electrochemistry (e.g., the corrosion of metal structures by oxidizing agents; industrial production of chlorine by electrolysis and its use in the purification of water).										
Number of clustered expectations										

Grade 12 Chemistry University: Structure and Properties

Overall Expectations **SPV.01** · demonstrate an understanding of quantum mechanical theory, and explain how types of chemical bonding account for the properties of ionic, molecular, covalent network, and metallic substances; **SPV.02** · investigate and compare the properties of solids and liquids, and use bonding theory to predict the shape of simple molecules; **SPV.03** · describe products and technologies whose development has depended on understanding molecular structure, and technologies that have advanced the knowledge of atomic and molecular theory.	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***Number of times***
Understanding Basic Concepts										
SP1.01 – explain the experimental observations and inferences made by Rutherford and Bohr in developing the planetary model of the hydrogen atom;										
SP1.02 – describe the quantum mechanical model of the atom (e.g., orbitals, electron probability density) and the contributions of individuals to this model (e.g., those of Planck, de Broglie, Einstein, Heisenberg, and Schrödinger);										
SP1.03 – list characteristics of the *s, p, d*, and *f* blocks of elements, and explain the relationship between position of elements in the periodic table, their properties, and their electron configurations;										
SP1.04 – explain how the properties of a solid or liquid (e.g., hardness, electrical conductivity, surface tension) depend on the nature of the particles present and the types of forces between them (e.g., covalent bonds, Van der Waals forces, dipole forces, and metallic bonds);										
SP1.05 – explain how the Valence Shell Electron Pair Repulsion (VSEPR) model can be used to predict molecular shape.										
Developing Skills of Inquiry and Communication										
SP2.01 – use appropriate scientific vocabulary to communicate ideas related to structure and bonding (e.g., *orbital, absorption spectrum, quantum, photon, dipole*);										
SP2.02 – write electron configurations for elements in the periodic table, using the Pauli exclusion principle and Hund's rule;										
SP2.03 – predict molecular shape for simple molecules and ions, using the VSEPR model;										
SP2.04 – predict the polarity of various substances, using molecular shape and the electronegativity values of the elements of the substances;										
SP2.05 – predict the type of solid (ionic, molecular, covalent network, or metallic) formed by a substance, and describe its properties;										
SP2.06 – conduct experiments to observe and analyse the physical properties of different substances, and to determine the type of bonding present.										
Relating Science to Technology, Society, and the Environment										
SP3.01 – describe some applications of principles relating to atomic and molecular structure in analytical chemistry and medical diagnosis (e.g., infrared spectroscopy, X-ray crystallography, nuclear medicine, medical applications of spectroscopy);										
SP3.02 – describe some specialized new materials that have been created on the basis of the findings of research on the structure of matter, chemical bonding, and other properties of matter (e.g., bulletproof fabric, superconductors, superglue);										
SP3.03 – describe advances in Canadian research on atomic and molecular theory (e.g., the work of Richard Bader at McMaster University in developing electron-density maps for small molecules; the work of R.J. LeRoy at the University of Waterloo in developing the mathematical technique for determining the radius of molecules called the LeRoy Radius).										
Number of clustered expectations										