OXFORD HIGH SCHOOL SCIENCE DEPARTMENT

ACADEMIC QUANTITATIVE CHEMISTRY CURRICULUM

#331 Quantitative Chemistry (A) (11-12) Full Year 1.0 Credit

This course is designed to be a hands-on inquiry-based exploration of chemistry. Always focused on making the connections between science and technology and their impact on the quality of our lives, the study of chemistry uses multiple pathways of scientific reasoning with specific emphasis on mathematical-analytical problem solving to explore atomic and molecular structure, chemical bonds, conservation of matter and stoichiometry, thermochemistry, acid-base chemistry, equilibrium, reaction rates, and organic chemistry. There are two prerequisites for this course - Geometry, Biology.

ENDURING UNDERSTANDINGS (BROAD IDEAS, USUALLY GROUNDED IN THE DISCIPLINE):

Science is a creative endeavor that uses logical, analytical processes.

SCIENTIFIC INQUIRY

- Scientific inquiry is a thoughtful and coordinated attempt to search out, describe, explain and predict natural phenomena.
- Scientific inquiry progresses through a continuous process of questioning, data collection, analysis and interpretation.
- Scientific inquiry requires the sharing of findings and ideas for critical review by colleagues and other scientists

SCIENTIFIC LITERACY

- Scientific literacy includes the ability to read, write, discuss and present coherent ideas about science.
- Scientific literacy also includes the ability to search for and assess the relevance and credibility of scientific information found in various print and electronic media.

SCIENTIFIC NUMERACY

- Scientific numeracy includes the ability to use mathematical operations and procedures to calculate, analyze and present scientific data and ideas.

COURSE SPECIFIC GOALS (ALIGNED WITH CONTENT STANDARDS):

SCIENTIFIC MEASUREMENT - Chemistry involves experimental and analytical investigations, and concepts are illustrated with practical applications that include examples. The use of laboratory techniques, manipulation of chemical quantities, and problem-solving applications are inherent throughout Chemistry.

MATTER AND CHANGE - Matter is made of atoms, atoms join to form compounds. The properties of a compound differ from the properties of the atoms that compose it. Matter can change forms through chemical reactions. Matter is classified according to its properties.

THE MOLE - Chemical compounds are analyzed quantitatively using molar mass as well as the unit "mole". A mole is also used throughout chemistry to stoichiometrically analyze chemical reactions.

CHEMICAL FORMULAE - Compounds in chemistry are classified according to the types of atoms of which they are composed. Chemical (IUPAC) nomenclature allows the scientific world to name and write formulas for matter using the same language.

CHEMICAL REACTIONS - In a chemical reaction, new substances are formed as atoms and molecules are rearranged. Properties of compounds can be used to identify newly formed products.

STOICHIOMETRY (CT-HSC-3) - The conservation of atoms in chemical reactions leads to the principle of conservation of matter and the ability to calculate the mass of products and reactants.

ATOMIC THEORY - The current model of the atom has been modified over time to incorporate scientific discoveries of many scientists. The current model consists of the view that particles compose an atom and relate to its structure and behavior. Changes in the nucleus of an atom result in emission of radioactivity.

ARRANGEMENT OF ELECTRONS IN ATOMS - There is a relationship between the energy changes in an atom and the movement of electrons between energy levels in an the atom. The movement of electrons results in the emission or absorption of quantum energy.

PERIODIC LAW (CT-HSC-1) - The periodic table displays the elements in increasing atomic number and shows how periodicity of the physical and chemical properties of the elements relates to atomic structure.

BONDING (CT-HSC-2) - Biological, chemical and physical properties of matter result from the ability of atoms to form bonds from electrostatic forces between electrons and protons and between atoms and molecules.

GASES - The kinetic molecular theory describes the motion of atoms and molecules and explains the properties of gases. Gas laws relate the pressure, temperature, and volume of any amount of an ideal gas or any mixture of ideal gases. There are conditions in which real gases deviate from ideal gas behavior.

SOLUTIONS - Solids, liquids, and gases dissolve to form solutions. The types and quantities of the solute and solvent determine if a solution will form and its new properties.

THERMOCHEMISTRY - Energy is transferred between objects/systems. If an object loses energy, something else must gain an equivalent amount of energy; the change in energy will result in changes of the kinetic and potential energy of the molecules involved.

KINETICS (CT-HSC-4) - Chemical reaction rates depend on factors influence the frequency of collision of reactant molecules.

EQUILIBRIUM - Many factors influence chemical reactions and some reactions can achieve a state of dynamic equilibrium.

ACIDS AND BASES - Acid and basic solutions can be determined by their hydrogen or hydroxide ion concentrations. Acids and bases undergo specific reactions with other species. Through the process of titrations, the concentration of unknown solutions can be determined.

ELECTROCHEMISTRY - Through the use of oxidations numbers, components of a chemical reaction undergoing oxidation and reduction can be identified. The transfer of electrons that is indicative of electrochemical reactions creates voltaic cells in which electrical energy can be harnessed from a chemical reaction.

ORGANIC CHEMISTRY (CT-HSC-5) - The bonding characteristics of carbon allow the formation of many different organic molecules of varied sizes, shapes and chemical properties, and provide the biochemical basis for life.

COMMON UNIT EXPECTED PERFORMANCES (ALIGNED WITH STATE EXPECTED PERFORMANCES):

Standard #	Standard/Expected Performance
C-1	Identify questions that can be answered through scientific investigation.
C-2	Read, interpret and examine the credibility and validity of scientific claims in different sources of information.
C-3	Design and conduct appropriate types of scientific investigations to answer different questions.
C-4	Identify independent variables, dependent variables, constants and controls in an experiment.
C-5	Use appropriate tools and techniques to make observations and gather data.
C-6	Use mathematical operations to analyze and interpret data, and present relationships between variables in appropriate forms.
C-7	Articulate conclusions and explanations based on research data, and assess results based on the design of the investigation.
C-7	Assess the reliability and validity of the data that was generated in an investigation and justify confidence in results.
C-8	Communicate about science in different formats, using relevant science vocabulary, supporting evidence and clear logic.
C-9	Identify an issue and its implications completely.
C-10	Develop an action plan that addresses all aspects of the issue in detail.
C-11	Use a variety of reliable sources of relevant information, data, knowledge, or experiences to take and support a critical stance.

UNIT I: SCIENTIFIC MEASUREMENT: CHEMISTRY INVOLVES EXPERIMENTAL AND ANALYTICAL INVESTIGATIONS, AND CONCEPTS ARE ILLUSTRATED WITH PRACTICAL APPLICATIONS THAT INCLUDE EXAMPLES. THE USE OF LABORATORY TECHNIQUES, MANIPULATION OF CHEMICAL QUANTITIES, AND PROBLEM-SOLVING APPLICATIONS ARE INHERENT THROUGHOUT CHEMISTRY.

Time: 1.5 weeks

Standard #	Standard/Expected Performance	Common Experiences
I-1	Use dimensional analysis to solve multi-step problems.	*Labs:* Mass, Volume, Density The Bunsen Burner: Orange vs. Blue Flames
I-2	To utilize SI units in measurements and calculations	
I-3	Calculate and compare the densities of solids, liquids, and gases.	
I-4	Graph experimental data, calculate slope, and extrapolate to identify unknown variables.	
I-5	Determine percent error and assess accuracy and precision of measurement	

UNIT II: MATTER AND CHANGE: MATTER IS MADE OF ATOMS, ATOMS JOIN TO FORM COMPOUNDS. THE PROPERTIES OF A COMPOUND DIFFER FROM THE PROPERTIES OF THE ATOMS THAT COMPOSE IT. MATTER CAN CHANGE FORMS THROUGH CHEMICAL REACTIONS. MATTER IS CLASSIFIED ACCORDING TO ITS PROPERTIES.

Time: 1.5 weeks

Standard #	Standard/Expected Performance	Common Experiences
II-1	Characterize the three states of matter by particle arrangement and intermolecular forces.	*Labs:* Observing a Chemical Reaction Physical & Chemical Changes *Common Experiences* Mixture Separation
II-2	Label the components of a phase diagram.	
II-3	Define and identify physical and chemical properties of matter.	
II-4	Define and identify physical and chemical changes that matter undergoes.	
II-5	Classify matter as an element, compound, mixture, or solution.	
II-6	Using physical properties of data, design a method to separate a heterogeneous mixture.	

UNIT III: THE MOLE: CHEMICAL COMPOUNDS ARE ANALYZED QUANTITATIVELY USING MOLAR MASS AS WELL AS THE UNIT "MOLE". A MOLE IS ALSO USED THROUGHOUT CHEMISTRY TO STOICHIOMETRICALLY ANALYZE CHEMICAL REACTIONS.

Time: 2 weeks

Standard #	Standard/Expected Performance	Common Experiences
III-1	Understand the basis for the masses of atoms based on one mole of carbon.	*Labs:* Determine the Percent of Water in a Hydrate Determine the Empirical Formula of a Compound Design a method to prepare a given molar solution. *Common Experiences* Determine the Percent of Oxygen in Potassium Chlorate
III-2	Understand the basis for the masses of atoms based on one mole of carbon.	
III-3	Understand the basis for the masses of atoms based on one mole of carbon.	
III-4	Understand the basis for the masses of atoms based on one mole of carbon.	
III-5	Perform calculations using Avogadro's number: 6.02×10^{23} (number of particles per mole).	
III-6	Determine the molar mass of a molecule from its formula and the Periodic Table.	
III-7	Calculate the percentage composition of various compounds.	
III-8	Analyze data to determine the empirical and molecular formulas of compounds.	
III-10	Calculate the molarity of a solution.	

UNIT IV: CHEMICAL FORMULAS: COMPOUNDS IN CHEMISTRY ARE CLASSIFIED ACCORDING TO THE TYPES OF ATOMS OF WHICH THEY ARE COMPOSED. CHEMICAL (IUPAC) NOMENCLATURE ALLOWS THE SCIENTIFIC WORLD TO NAME AND WRITE FORMULAS FOR MATTER USING THE SAME LANGUAGE.

Time: 1.5 weeks

Standard #	Standard/Expected Performance	Common Experiences
IV-1	Identify the subatomic particles in an atom.	*Labs:* Empirical Formula of a Compound
IV-2	Differentiate between atoms and ions, ionic compounds and molecular compounds.	
IV-3	Write formulas and name: a. binary ionic compounds b. binary molecular compounds c. ternary compounds d. compounds involving transitions metals e. acids	

UNIT V: CHEMICAL REACTIONS: IN A CHEMICAL REACTION, NEW SUBSTANCES ARE FORMED AS ATOMS AND MOLECULES ARE REARRANGED. PROPERTIES OF COMPOUNDS CAN BE USED TO IDENTIFY NEWLY FORMED PRODUCTS.

Time: 2 weeks

Standard #	Standard/Expected Performance	Common Experiences
V-1	Identify reactants and products of a chemical reaction.	*Labs:* Classifying, Predicting, & Verifying Reactions *Common Experiences:* Mystery Solutions
V-2	Complete, write and balance chemical equations that represent the following reaction types: a. Synthesis b. Decomposition c. Single Replacement d. Double Displacement e. Combustion	
V-3	Utilize the Activity Series to determine if a reaction occurs.	
V-4	Utilize a solubility chart to determine if a reaction occurs.	

Unit VI: STOICHIOMETRY: CT-HSC-3. The conservation of atoms in chemical reactions leads to the principle of conservation of matter and the ability to calculate the mass of products and reactants.

Time: 2 weeks

Standard #	Standard/Expected Performance	Common Experiences
VI-1	Construct mole ratios from balanced equations.	*Labs:* Mass-Mass
VI-2	Convert amongst amount of reactants and products using mass and moles using balanced chemical equations.	
VI-3	Analyze a reaction to determine the percentage yield.	
VI-4	Explain percentage error of theoretical vs. experimental yields obtained from class data.	

UNIT VII: ATOMIC THEORY: THE CURRENT MODEL OF THE ATOM HAS BEEN MODIFIED OVER TIME TO INCORPORATE SCIENTIFIC DISCOVERIES OF MANY SCIENTISTS. THE CURRENT MODEL CONSISTS OF THE VIEW THAT PARTICLES COMPOSE AN ATOM AND RELATE TO ITS STRUCTURE AND BEHAVIOR. CHANGES IN THE NUCLEUS OF AN ATOM RESULT IN EMISSION OF RADIOACTIVITY.

Time: 2 weeks

Standard #	Standard/Expected Performance	Common Experiences
VII-1	Explain the reason for the difference between the relative size of an atom to its mass.	*Labs:* Conservation of Mass
VII-2	Explain the development of the model of the atom including the contributions and shortcomings of: a. The Early Greek Philosophers b. John Dalton c. J. J. Thomson d. Lord Ernest Rutherford e. Neils Bohr f. Quantum Mechanical Model	
VII-3	Identify the three subatomic particles and their functions in an atom.	
VII-4	Use alpha and beta particles to write nuclear reactions.	
VII-5	Determine the age of a material using its half life. Understand the relationship between mass defect and binding energy.	
VII-6	Calculate the average atomic mass of a set of isotopes.	

UNIT VIII: ARRANGEMENT OF ELECTRONS IN ATOMS: THERE IS A RELATIONSHIP BETWEEN THE ENERGY CHANGES IN AN ATOM AND THE MOVEMENT OF ELECTRONS BETWEEN ENERGY LEVELS IN AN THE ATOM. THE MOVEMENT OF ELECTRONS RESULTS IN THE EMISSION OR ABSORPTION OF QUANTUM ENERGY.

Time: 1.5 weeks

Standard #	Standard/Expected Performance	Common Experiences
VIII-1	Write the electron configurations, orbital filling diagrams, and Lewis Dot Structures of elements.	*Common Experiences:* Flame Tests
VIII-2	Use the position of an element on the periodic table to determine its atomic number, electron configuration, and physical and chemical properties.	

UNIT IX: PERIODIC LAW: CT-HSC-1.THE PERIODIC TABLE DISPLAYS THE ELEMENTS IN INCREASING ATOMIC NUMBER AND SHOWS HOW PERIODICITY OF THE PHYSICAL AND CHEMICAL PROPERTIES OF THE ELEMENTS RELATES TO ATOMIC STRUCTURE.

Time: 1.5 weeks

Standard #	Standard/Expected Performance	Common Experiences
IX-1	Use the periodic table to identify metals, nonmetals, and metalloids.	*Labs:* Reactivity of Halides Reactivity of Metals
IX-2	Use the periodic table to identify metals, nonmetals, and metalloids.	
IX-3	Differentiate between periods and families of the periodic table; classify elements according to families.	
IX-4	Identify trends in ionization energy, atomic and ionic radius, electronegativity, and electron affinity using the periodic table.	
IX-5	Explain the contributions of Mendeleyev and Moseley to the construction of the Modern Periodic Table.	

UNIT X: BONDING: CT-HSC-2. BIOLOGICAL, CHEMICAL AND PHYSICAL PROPERTIES OF MATTER RESULT FROM THE ABILITY OF ATOMS TO FORM BONDS FROM ELECTROSTATIC FORCES BETWEEN ELECTRONS AND PROTONS AND BETWEEN ATOMS AND MOLECULES.

Time: 2 weeks

Standard #	Standard/Expected Performance	Common Experiences
X-1	Combine atoms to form molecules by sharing electrons to form covalent or metallic bonds or by exchanging electrons to form ionic bonds.	*Labs:* Molecular Models
X-2	Compare and contrast ionic, covalent, and metallic bonding.	
X-3	Compare and contrast intermolecular and intramolecular forces.	
X-4	Classify chemical bonds between atoms in molecules such as H2, CH4, NH3, H2CCH2, N2, Cl2, and many large biological molecules as covalent.	
X-5	Recognize that salt crystals, such as NaCl, are repeating patterns of positive and negative ions held together by electrostatic attraction.	
X-6	Understand that the atoms and molecules in liquids move in a random pattern relative to one another because the intermolecular forces are too weak to hold the atoms or molecules in a solid form.	
X-7	Draw Lewis dot structures to provide models of atoms and molecules.	
X-8	Predict the shape of molecules and their polarity from Lewis dot structures and VSEPR.	
X-9	Explain how electronegativity and ionization energy are related to bond formation.	

UNIT XI: GASES: THE KINETIC MOLECULAR THEORY DESCRIBES THE MOTION OF ATOMS AND MOLECULES AND EXPLAINS THE PROPERTIES OF GASES. GAS LAWS RELATE THE PRESSURE, TEMPERATURE, AND VOLUME OF ANY AMOUNT OF AN IDEAL GAS OR ANY MIXTURE OF IDEAL GASES. THERE ARE CONDITIONS IN WHICH REAL GASES DEVIATE FROM IDEAL GAS BEHAVIOR.

Time: 2 weeks

Standard #	Standard/Expected Performance	Common Experiences
XI-1	Describe the motion of gases molecules according to the Kinetic Molecular Theory of Gases.	*Labs:* Charles' Law Lab Boyle's Law Virtual Lab Diffusion of Gases
XI-2	Compare and contrast barometers and manometers as well as the different pressure units.	
XI-3	Discuss the significance of absolute zero and the Absolute Temperature Scale.	
XI-4	Utilize standard temperature and pressure in gas law problems.	
XI-5	Calculate gas parameter using Boyle's, Charles', and the Combined Gas Laws.	
XI-6	Compare and contrast the behaviors of ideal vs. real gases.	
XI-7	Using the Ideal Gas Law, determine the density and molar mass of gases.	
XI-9	Explain the relationship between a mixture of gases and their total pressure.	
XI-10	Compare and contrast the velocities of different gases at the same temperature and pressure.	

UNIT XII: SOLUTIONS: SOLIDS, LIQUIDS, AND GASES DISSOLVE TO FORM SOLUTIONS. THE TYPES AND QUANTITIES OF THE SOLUTE AND SOLVENT DETERMINE IF A SOLUTION WILL FORM AND ITS NEW PROPERTIES.

Time: 2.5 weeks

Standard #	Standard/Expected Performance	Common Experiences
XII-1	Define solute, solvent, solution, aqueous, saturated, unsaturated, and supersaturated.	*Labs:* Solubility Curves
XII-2	Explain "Like Dissolves Like".	
XII-3	Determine and explain how several factors influence the rate of solvation.	
XII-4	Analyze solubility curves to determine if a solution is saturated, the amount of water to prepare a saturated solution, or the relationship between solute and solvent and various temperatures.	
XII-5	Write net ionic equations for reactions of aqueous solutions.	
XII-6	Calculate the molality of a solution and use it to determine the freezing and boiling points of solutions.	

UNIT XIII: THERMOCHEMISTRY: ENERGY IS TRANSFERRED BETWEEN OBJECTS/SYSTEMS. IF AN OBJECT LOSES ENERGY, SOMETHING ELSE MUST GAIN AN EQUIVALENT AMOUNT OF ENERGY; THE CHANGE IN ENERGY WILL RESULT IN CHANGES OF THE KINETIC AND POTENTIAL ENERGY OF THE MOLECULES INVOLVED.

Time: 2 weeks

Standard #	Standard/Expected Performance	Common Experiences
XIII-1	Identify and compare and contrast the different types of energy involved in phase changes of a substance.	*Labs:* Heat of Fusion of Ice Heat of Reaction *Common Experiences:* Lab: Specific Heat of a Metal
XIII-2	Calculate the heat involved in a phase change using specific heats and calorimetry.	
XIII-3	Identify and interpret information on a potential energy diagram.	
XIII-4	Use Hess's Law to calculate enthalpy change in a reaction.	

UNIT XIV: KINETICS: CT-HSC-4. CHEMICAL REACTION RATES DEPEND ON FACTORS INFLUENCE THE FREQUENCY OF COLLISION OF REACTANT MOLECULES.

Time: 2 weeks

Standard #	Standard/Expected Performance	Common Experiences
XIV-1	Determine the effect of concentration, pressure, catalysts, and temperature on rate of reaction.	*Labs:* Rate of Reaction
XIV-2	Define a reaction mechanism and explain how the rate determining step affects the rate of the overall reaction.	

Web Resources:
Collision Theory Animation: http://www.saskschools.ca/curr_content/chem30_05/2_kinetics/kinetics2_1.htm
Collision Theory Animation: http://chem.salve.edu/chemistry/temp2a.asp#animation

UNIT XV: EQUILIBRIUM: MANY FACTORS INFLUENCE CHEMICAL REACTIONS AND SOME REACTIONS CAN ACHIEVE A STATE OF DYNAMIC EQUILIBRIUM.

Time: 2 weeks

Standard #	Standard/Expected Performance	Common Experiences
XV-1	Define a system in equilibrium and relate it to the rates of the forward and reverse reactions.	*Labs:* LeChatelier's Principle
XV-2	Write the equilibrium constant and explain how it relates to a given reaction.	
XV-3	Analyze an equilibrium constant to determine the extent of a reaction.	
XV-4	Apply changes in temperature, pressure, common ions, and concentration to LeChatelier's Principle.	

UNIT XVI: ACIDS AND BASES: ACID AND BASIC SOLUTIONS CAN BE DETERMINED BY THEIR HYDROGEN OR HYDROXIDE ION CONCENTRATIONS. ACIDS AND BASES UNDERGO SPECIFIC REACTIONS WITH OTHER SPECIES. THROUGH THE PROCESS OF TITRATIONS, THE CONCENTRATION OF UNKNOWN SOLUTIONS CAN BE DETERMINED.

Time: 2 weeks

Standard #	Standard/Expected Performance	Common Experiences
XVI-1	Differentiate between acids and bases according to the Arrhenius, and Bronsted-Lowry theories.	*Labs:* Introduction and Properties of Acids and Bases *Common Experiences:* Titration Analyses
XVI-2	Explain the use of indicators.	
XVI-3	Describe and identify neutralization reactions.	
XVI-4	Perform acid-base titrations and analyze data to determine molarity of unknown.	
XVI-5	Calculate pH, pOH, [H+] and [OH-] for both strong and weak acids and bases.	

UNIT XVII: ELECTROCHEMISTRY: THROUGH THE USE OF OXIDATIONS NUMBERS, COMPONENTS OF A CHEMICAL REACTION UNDERGOING OXIDATION AND REDUCTION CAN BE IDENTIFIED. THE TRANSFER OF ELECTRONS THAT IS INDICATIVE OF ELECTROCHEMICAL REACTIONS CREATES VOLTAIC CELLS IN WHICH ELECTRICAL ENERGY CAN BE HARNESSED FROM A CHEMICAL REACTION.

Time: 1.5 weeks

Standard #	Standard/Expected Performance	Common Experiences
XVII-1	Relate electron transfer to oxidation-reduction reactions and electrochemical cells.	*Labs:* Determining Cell Voltage Daniell Cells Redox Reactions *Common Experiences:* Draw and label all components of a voltaic cell.
XVII-3	Relate electron transfer to oxidation-reduction reactions and electrochemical cells. Sketch and label all components of a voltaic cell.	
XVII-4	Determine cell voltage.	

UNIT XVIII: ORGANIC CHEMISTRY: CT-HSC-5. THE BONDING CHARACTERISTICS OF CARBON ALLOW THE FORMATION OF MANY DIFFERENT ORGANIC MOLECULES OF VARIED SIZES, SHAPES AND CHEMICAL PROPERTIES, AND PROVIDE THE BIOCHEMICAL BASIS FOR LIFE.

Time: 1.5 weeks

Standard #	Standard/Expected Performance	Common Experiences
XVIII-1	Understand that the bonding characteristics of carbon result in the formation of a large variety of structures, ranging from simple hydrocarbons to complex biological molecules and synthetic polymers.	*Labs:* Polymers
XVIII-2	Describe various hydrocarbon classes, their sources and uses; draw and name their constituents.	
XVIII-3	Describe polymerization reactions and uses of polymers.	
XVIII-4	Explain the role of proteins, amino acids, and lipids in living organisms.	
XVIII-5	Describe nucleic acids and how they relate to DNA and RNA.	

UNIT	TIME FRAME
Scientific Measurement	2.5 weeks
Matter and Change	1.5 weeks
The Mole	2 weeks
Chemical Formulas	1.5 weeks
Chemical Reactions	2 weeks
Stoichiometry	2 weeks
Atomic Theory	2 weeks
Arrangement of Electrons in Atoms	1.5 weeks
Periodic Law	1.5 weeks
Bonding	2 weeks
Gases	2 weeks
Solutions	2.5 weeks
Kinetics	2 weeks
Thermochemistry	2 weeks
Equilibrium	2 weeks
Acids and Bases	2 weeks
Electrochemistry	1.5 weeks
Organic Chemistry	1.5 weeks