Oakwood City School District: Chemistry

Chemistry is a college preparatory course designed for the intermediate to advanced science student. Chemistry is the science of matter and focuses on its structure, change and composition. This course of study addresses the following fields: atomic structure and electron configuration, chemical bonding, change of phases, ionization and equilibrium, solutions and suspensions, organic compounds, and nuclear chemistry. This course is designed to establish a firm foundation for students preparing to pursue the technical degrees related to the physical sciences. A direct objective is to promote an atmosphere of scientific inquiry through the application of the scientific method.

This course fulfills the graduation requirements of either a physical science or an advanced science for the State of Ohio. Students may elect to use credit in General Chemistry to fulfill their physical science requirement in lieu of the Physical Science course, or students may elect to General Chemistry credit fulfill an advance science requirement when taking the course after successfully completing the Physical Science course. Students who elect to take General Chemistry in lieu of the full Physical Science course must also complete Physics (or the second semester in Physical Science) and take the end of course exam for Physical Science.

Science Inquiry and Application Standards

During the years of grades 9 through 12 all students must use the following scientif processes with appropriate laboratory safety techniques to construct their knowledge and understanding in all science content areas. These are ongoin skills that will be developed and intertwined within the content of each course.

- Identify questions and concepts that guide scientific investigations
- Design and conduct scientific investigations
- Use technology and mathematics to improve investigations and communications
- Formulate and revise explanations and models using logic and evidence (critical thinking)
- Recognize and analyze explanations and models
- Communicate and support a scientific argument
- Research and apply appropriate safety precautions when designing and conducting scientific investigations (e.g. OSHA, MSDS, eyewash, goggles, ventilation).
- Explain why the methods of an investigation are based on the questions being asked.

- Summarize data and construct a reasonable argument based on those data and other known information
- Use mathematical models to predict and analyze natural phenomena.
- Derive simple mathematical relationships that have predictive power from experimental data (e.g., derive an equation from a graph and vice versa, determine whether a linear or exponential relationship exists among the data in a table).
- Use appropriate summary statistics to analyze and describe data.
- Present scientific findings using clear language, accurate data, appropriate graphs, tables, maps and available technology.
- Recognize that bias affects outcomes. People tend to ignore evidence that challenges their beliefs but accept evidence that supports their beliefs. Scientists attempt to avoid bias in their work.
- Use historical examples to explain how new ideas are limited by the context in which they are conceived; are often initially rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly through contributions from many different investigators (e.g., atomic theory, quantum theory, Newtonian mechanics).

English Language Arts Standards for Science & Technical Subjects

Key Ideas and Details

- RST.9-10.1. Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
- RST.9-10.2. Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.
- RST.9-10.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

Craft and Structure

- RST.9-10.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 9–10 texts and topics*.
- RST.9-10.5. Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., *force, friction, reaction force, energy*).
- RST.9-10.6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.

Integration of Knowledge and Ideas

- RST.9-10.7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
- RST.9-10.8. Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.
- RST.9-10.9. Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.

Range of Reading and Level of Text Complexity

- RST.9-10.10. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

English Language Arts Standards for Science & Technical Subjects

Key Ideas and Details

- RST.11-12.1. Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- RST.11-12.2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
- RST.11-12.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

Craft and Structure

- RST.11-12.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 11–12 texts and topics*.
- RST.11-12.5. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.
- RST.11-12.6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.

Integration of Knowledge and Ideas

- RST.11-12.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
- RST.11-12.8. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
- RST.11-12.9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Range of Reading and Level of Text Complexity

- RST.11-12.10. By the end of grade 12, read and comprehend science/technical texts in the grades 11–12 text complexity band independently and proficiently.

Content Standards

I Structure and Properties of Matter

A Atomic Structure

1 Evolution of atomic models/theory
(a) Describe Dalton's Atomic Theory and Law of constant composition.
(b) Describe the basic parts of the atom and the experiments that lead to their discovery.
(c) Explain that the electric force between the nucleus and the electrons hold an atom together.
(d) Illustrate that atoms with the same number of positively charged protons and negatively charged electrons are electrically neutral.
(e) Demonstrate that electromagnetic radiation is a form of energy. Recognize that light acts as a wave. Show that visible light is a part of the electromagnetic spectrum (e.g., radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays).
(f) Explain how atoms and molecules can gain or lose energy in particular discrete amounts (quanta or packets); therefore they can only absorb or emit light at the wavelengths corresponding to these amounts.

2 Electrons
(a) Demonstrate how ions combine to form neutral compounds.

3 Electron Configurations

(a) Recognize that the periodic table was formed as a result of the repeating pattern of electron configurations.
(b) Describe how different atomic energy levels are associated with the electron configurations of atoms and electron configurations (and/or conformations) of molecules.
(c) Learn about shapes of orbitals designated by s, p, d and f.

B Periodic Table

1 Properties
(a) Communicate using names and symbols of select elements.
(b) Show that elements listed in increasing the number of protons (called the atomic number), create repeating patterns of physical and chemical properties and identify elements with similar properties as families.
(c) Recognize that all atoms of the same element contain the same number of protons, and elements with the same number of protons may or may not have the same mass. Those with different masses (different numbers of neutrons) are called isotopes.

2 Trends
(a) Learn how the periodic table can help predict the ion charge a given element will develop.
(b) Learn how the periodic table reveals trends in the physical and chemical properties of elements.
(c) Understand general trends in atomic properties in the periodic table.
(d) Understand factors governing ionic size

C Mathematical Chemistry

1 Fundamental Calculations
(a) Use scientific notation to show how very large or very small numbers can be expresses as the product of a number between 1 and 10 and a power of 10.
(b) Describe and calculate measurements with English, metric, and SI systems (including mass, length, volume, density).
(c) Recognize and express uncertainty in measurements by using significant figures.
(d) Demonstrate the use of dimensional analysis to solve problems.
(e) Express and convert between temperature scales.
(f) Demonstrate that reliable scientific evidence improves the ability of scientists to offer accurate predictions.

2 Quantifying Matter/Mole Concept
(a) Explain average atomic mass and utilize weighing as a means of counting atoms.
(b) Describe and perform mathematical calculations using mole concept and Avogadro's number.

(c) Determine chemical composition based on chemical formula and vice versa.
(d) Determine and utilize the molar mass of compounds to mathematically convert between mass and moles.
(e) Describe the composition of compounds using percentages (by mass).
(f) Describe and calculate the empirical formula of compounds from mass percentages.
(g) Determine and explain the relationship between empirical and molecular formula.

D Intramolecular Chemical Bonding

1 Ionic
(a) Learn about ionic bonds and explain how they are formed.

2 Polar/Covalent
(a) Learn about covalent bonds and explain how they are formed.
(b) Predict molecular geometry from the number of valence shell electron pairs.
(c) Understand bond polarity and how it relates to molecular polarity.

E Representing compounds

1 Formula Writing
(a) Write the formula of a compound given its name

2 Nomenclature
(a) Understand and communicate the relation between the name and formula of simple binary ionic compounds.
(b) Understand and communicate the relation between the name and formula of binary ionic compounds that contain transition metals.
(c) Understand and communicate the relation between the name and formula of molecules that contain nonmetals.
(d) Understand and communicate the relation between the name and formula of ionic compounds that contain polyatomic ions.
(e) Understand and communicate the relation between the name and formula of common acids and bases.

3 Models and shapes (Lewis structures, ball and stick, molecular geometries)
(a) Learn to write Lewis Structures.

(b) Explain how atoms join with one another in various combinations in distinct molecules or in repeating crystal patterns.

F Intermolecular Chemical Bonding

1 Types and Strengths
(a) Learn about dipole-dipole attraction, hydrogen bonding and London dispersion forces. Understand the effect of these forces on the properties of liquids.
(b) Understand the inter-particle forces in crystalline solids. Learn about how the bonding in metals determines metallic properties.

2 Implications for properties of substances (melting and boiling, solubility, vapor pressure)
(a) Utilize solubility indicators to predict the formation of precipitants.
(b) Understand the relationship among vaporization, condensation, and vapor pressure.

3 Phases of Matter
(a) Describe the three states of matter.
(b) Distinguish between physical and chemical properties and changes in these properties.
(c) Classify chemicals as mixtures, pure substances, compound, and elements.
(d) Investigate the properties of pure substances and mixtures (e.g., density, conductivity, hardness, properties of alloys, superconductors and semiconductors).
(e) Illustrate that chemical reactions are either endothermic or exothermic (e.g., cold packs, hot packs and the burning of fossil fuels).
(f) Describe real world entropic examples showing that all energy transformations tend toward disorganized states (e.g., fossil fuel combustion, food pyramids, electrical use).
(g) Recognize that at low temperatures some materials become superconducting and offer little or no resistance to the flow of electrons.

II Interactions of Matter

A Chemical Reactions

1 Introduction to Reactions
(a) Describe and utilize factors that indicate the likelihood a reaction will occur between given reactants.

(b) Describe the information provided by a balanced chemical equation.
(c) Show how atoms may be bonded together by losing, gaining or sharing electrons and that in a chemical reaction, the number, type of atoms and total mass must be the same before and after the reaction (e.g., writing correct chemical formulas and writing balanced chemical equations).

2 Types of Reactions
(a) Illustrate aqueous ionic reactions with various chemical equations (including complete and net ionic reactions).
(b) Classify chemical reactions into general categories (single replacement, double replacement, acid-base, oxidation-reduction, combustion, decomposition, synthesis)
(c) Investigate the properties of pure substances and mixtures (e.g., density, conductivity, hardness, properties of alloys, superconductors and semiconductors).
(d) Recognize and identify the evidence for a chemical reaction.
(e) Identify the characteristics of chemical reactions and the information conveyed in chemical equations.
(f) Demonstrate the ability to balance chemical equations.
(g) Redox Reactions:
(i) Describe the characteristic reactions between metals and nonmetals where electron transfer is the driving force for the reaction (oxidation-reduction reactions).
(ii) Learn to balance oxidation-reduction equations by using half-reactions.
(iii) Learn to identify the components of an electrochemical cell.
(iv) Understand the process of electrolysis and apply it to several industrial processes.

3 Kinetics
(a) Be able to draw potential energy diagrams for chemical systems and determine if they are exothermic or endothermic
(b) Define and explain the concept of a reaction mechanism
(c) Relate the activation energy to the enthalpy of a chemical reaction
(d) Define and describe molecular characteristics of the activated complex
(e) Be able to discuss factors that influence reaction rates
(f) Explain and write rate laws for chemical reactions
(g) Relate the order of reaction to the rate law for the reaction

(h) Define catalyst and discuss the requirements of a homogeneous and heterogeneous catalyst

4 Energy
(a) Explain how thermal energy exists in the random motion and vibrations of atoms and molecules. Recognize that the higher the temperature, the greater the average atomic or molecular motion and that during changes of state the temperature remains constant.
(b) Explain how an object's kinetic energy depends on its mass and its speed (KE = ½ mv2).
(c) Understand that on a larger scale, electric forces hold solid and liquid materials together (e.g. salt crystals, water).
(d) Understand and apply the heat of fusion and heat of vaporization to a set of experimental conditions.

5 Equilibrium
(a) Describe how a physical, chemical or ecological system in equilibrium may return to the same state of equilibrium if the disturbances it experiences are small. Large disturbances may cause it to escape that equilibrium and eventually settle into a new state of equilibrium.
(b) Understand the collision model for how chemical reactions occur.
(c) Understand and define the term activation energy.
(d) Learn the chemical characteristics of chemical equilibrium.
(e) Learn how to calculate values for equilibrium constants of various chemical reactions.
(f) Learn to calculate the solubility product of a salt, given its solubility.

6 Acids/Bases
(a) Describe the characteristics of a reaction between strong acids and bases.
(b) Learn about two models of acids and bases and the relationship of conjugate acid-base pairs.
(c) Understand what acid strength represents by evaluating the relationship between acid strength and the strength of the conjugate base.
(d) Demonstrate that the pH scale (0-14) is used to measure acidity and classify substances or solutions as acidic, basic, or neutral.
(e) Learn to calculate the pH of a solution of strong acids and bases.
(f) Understand the general characteristics of buffered solutions.

B Gas Laws
1 Pressure, volume, and temperature
(a) Learn about atmospheric pressure and how barometers work.
(b) Learn how materials and molecules behave under pressure, volume, and temperature constraints.
2 Ideal Gas law
(a) Understand the law that related the pressure and volume of gas
(b) Learn about the law relating volume and temperature of a sample of gas at constant moles and pressure, and do calculations involving the law.
(c) Learn to calculate the relationships between temperature, volume, pressure and number of moles of gas particles.

C Stoichiometry
1 Molar Calculations
(a) Describe the information provide by a balanced chemical equation.
(b) Utilize balanced chemical equations and mass-mole relationships to determine the relationship between moles of reactants and moles of products.
(c) Utilize balanced chemical equations and mass-mole relationships to determine the relationship between masses of reactants and masses of products.
2 Limiting Reagents
(a) Determine the limiting reactant and how it affects the final quantities of reactions.
(b) Determine the percent yield from the actual and theoretical yields of reactions.

D Solutions
1 Terminology and Concepts
(a) Understand the process of dissolution
(b) Understand the concentration term mass percent and learn how to calculate it
(c) Compare the conductivity of different materials and explain the role of electrons in the ability to conduct electricity.

2 Calculations
(a) Define molarity and use it to calculate the number of moles of a solute present.
(b) Apply normality and equivalent weight to stoichiometric calculations in aqueous reactions

E Nuclear Reactions

1 Radioisotopes
(a) Describe radioactive substances as unstable nuclei that undergo random spontaneous nuclear decay emitting particles and/or high-energy wavelike radiation.
(b) Explain the characteristics of isotopes. The nucleus of a radioactive isotope is unstable and spontaneously decays emitting particles and/or wavelike radiation. It cannot be predicted exactly when, if ever, an unstable nucleus will decay, but a large group of identical nuclei decay at a predictable rate.

2 Nuclear Energy
(a) Summarize how nuclear reactions convert a small amount of matter into a large amount of energy. (Fission involves the splitting of a large nucleus into smaller nuclei; fusion is the joining of two small nuclei into a larger nucleus at extremely high energies.)
(b) Recognize that nuclear forces are much stronger than electromagnetic forces, and electromagnetic forces are vastly stronger than gravitational forces. The strength of the nuclear forces explains why greater amounts of energy are released from nuclear reactions (e.g., from atomic and hydrogen bombs and in the Sun and other stars).
(c) Use the predictability of decay rates and the concept of half-life to explain how radioactive substances can be used in estimating the age of materials.
(d) Investigate that all fuels (e.g., fossil, solar, nuclear) have advantages and disadvantages; therefore society must consider the trade-offs among them (e.g., economic costs and environmental impact).
(e) Recognize that scientific knowledge and explanations have changed over time, almost always building on earlier knowledge.
(f) Recognize that ethical considerations limit what scientists can do.
(g) Explain how natural and human-induced hazards present the need for humans to assess potential danger and risk. Many changes in the environment designed by humans bring benefits to society as well as cause risks.