VALWOOD

GO BEYOND

Chemistry Curriculum

Chemistry Overview

Course Description	Topics at a Glance
This course provides the opportunity to develop knowledge and understanding about the relationships between the structure and properties of matter and the interaction of matter and energy. Units of study include: matter and its changes, atomic structure, chemical composition, nomenclature, acids and bases, reactions, stoichiometry, gas laws, periodicity, bonding, molecular geometry, and thermochemistry. Laboratory activities reinforce concepts presented in the course.	• Atomic Theory • Normenclature • Lab Practices • Chemical Reactions • Mathematical Tools in chemistry • The Mole Concept • Stoichiometry • Solutions • Quantum Theory and the Periodic Table • Bonding • Kinetics and Equilbrium • Thermochemistry • Gases • Nuclear reactions and decay
Assessments	
• Teacher-created assessments • Assesments Adopted from course materials	

Standard	
1. Physical Science	1. The nature of chemical bonding in a substance determines its physical and chemical properties. 2. Matter has properties related to its structure that can be measured and used to identify, classify and describe substances or objects. 3. The effects of temperature, pressure and volume of a quantity of gas can be predicted and measured experimentally, and can be explained by the Kinetic Molecular Theory. 4. The rate (speed) of a reaction depends on a variety of factors. Equilibrium is a dynamic process in which the forward rate of a reaction is the same as the reverse rate of a reaction, and the concentrations of reactants and products no longer change. 5. Scientists ask questions and state hypotheses using prior knowledge to help design and guide scientific investigations, using appropriate technology and safe laboratory practices. 6. Scientists use the tools of math to solve problems, analyze data, and evaluate the validity of results. 7. Matter can neither be created nor destroyed. The mole concept allows chemists to link the atomic world with the macroscopic world through the use of the periodic table. Stoichiometric relationships are used to determine "how much is needed" and "how much can be produced" in chemical reactions. 8. Chemical reactions occur all around us and may either release or consume energy. A large number of reactions involve the transfer of either electrons or hydrogen ions. 9. Observed properties such as light emission and absorption and chemical reactivity can be related to electron configuration and nuclear charge. 10. Solutions need to be clearly described according to the substances and their amounts, including the interactions of the substances in a solution. 11. Temperature of a sample is related to the kinetic energy of the particles in the sample. Heat flows from a warmer object to a cooler object, and heat loss by a system equals heat gain by the surroundings (and vice versa).

1. Physical Science

Students know and understand common properties, forms and changes in matter and energy.

Valwood Graduate Competencies
The Valwood graduate competencies are the preschool through twelfth-grade concepts and skills that all graduates will be able to demonstrate.

Valwood Graduate Competencies in the Physical Science standard:

- Observe, explain, and predict natural phenomena governed by Newton's laws of motion, acknowledging the limitations of their application to very small or very fast objects
- Apply an understanding of atomic and molecular structure to explain the properties of matter, and predict outcomes of chemical and nuclear reactions
- Apply an understanding that energy exists in various forms, and its transformation and conservation occur in processes that are predictable and measurable
- *Engage in scientific inquiry by asking or responding to scientifically oriented questions, collecting and analyzing data, giving priority to evidence, formulating explanations based on evidence, connecting explanations to scientific knowledge, and communicating and justifying explanations.*

Content Area: Science - Chemistry

Standard: 1. Physical Science

Valwood Graduates:

Apply an understanding of atomic and molecular structure to explain the properties of matter, and predict outcomes of chemical and nuclear reactions

GRADE LEVEL EXPECTATION

Concepts and skills students master:

1. The nature of chemical bonding in a substance determines its physical and chemical properties

Evidence Outcomes	**21st Century Skills and Readiness Competencies**
Students can: a. Discriminate between ionic compounds and covalently bonded molecules based on the electronegativity differences between the atoms in the compound. b. Describe bonding in metals c. Understand the continuum between purely non-polar covalent, polar covalent, and ionic substances d. Describe the nature of intermolecular attractive forces: hydrogen bonding, dipole-dipole, and London/Dispersion e. Distinguish between a chemical bond and an intermolecular attractive force f. Explain observations of chemical and physical properties according to the nature of bonding within the substance g. Use models to represent relationships of atoms in substances and represent positions of electrons in compounds using Lewis structures h. Use VSEPR (Valence Shell Electron Pair Repulsion) Theory to represent the three-dimensional geometry of atoms in covalently bonded substances	**Inquiry Question:** 1. How does the kind of chemical bonding give rise to the properties of a substance? **Relevance and Application:** 1. Almost all substances we encounter (and are made out of) are composed of elements chemically bonded to each other. 2. The shape of water molecules and the strong permanent dipole of the molecule result in water's high vapor pressure, outstanding ability to act as a solvent, and its having a lower density as a solid than as a liquid. **Nature of Discipline:**

Content Area: Science - Chemistry

Standard: 1. Physical Science

Valwood Graduates:

Apply an understanding of atomic and molecular structure to explain the properties of matter, and predict outcomes of chemical and nuclear reactions

GRADE LEVEL EXPECTATION

Concepts and skills students master:

2. Matter has properties related to its structure that can be measured and used to identify, classify and describe substances or objects

Evidence Outcomes	**21st Century Skills and Readiness Competencies**
Students can: a. Compare and contrast physical and chemical changes. b. Demonstrate physical and chemical methods used to separate mixtures that are based on the properties of the substances c. Describe the atom's structure (including electron energy levels, atomic orbitals, and electron configurations) using evidence from the modern atomic theory d. Determine the atomic number and mass number of isotopes e. Calculate the average atomic mass of an element	**Inquiry Question:** 1. What is stuff made of and how do we know? **Relevance and Application:** 1. Advances in technology, particularly in spectroscopy and microscopy, have allowed scientists to develop a more detailed understanding of the atom. 2. New materials used in engineering are designed at the atomic level. 3. Experiments and chemical processes are designed according to the properties of the substances involved: for example, substances with very different boiling points can be separated via distillation. **Nature of Discipline:** 1. Use scientific concepts to explain the nature of the world around them. 2. Understand that all scientific knowledge is subject to new findings and that scientific theories are supported by reproducible results. 3. Employ data-collection technology to gather, view, analyze, and interpret data about chemical and physical properties of different compounds. 4. Critically evaluate chemical and nuclear change models.

Content Area: Science - Chemistry

Standard: 1. Physical Science

Valwood Graduates:

Apply an understanding of atomic and molecular structure to explain the properties of matter, and predict outcomes of chemical and nuclear reactions

GRADE LEVEL EXPECTATION

Concepts and skills students master:

3. The effects of temperature, pressure and volume on a quantity of gas can be predicted and measured experimentally, and can be explained by the Kinetic Molecular Theory

Evidence Outcomes	**21st Century Skills and Readiness Competencies**
Students can: a. Use the gas laws, including the ideal gas law, to calculate the volume, pressure, temperature, or the molar mass of a gas b. Explain and use Dalton's Law of Partial Pressures c. Compare the properties of real and ideal gases d. Qualitatively describe how the Kinetic Molecular Theory describes the macroscopic properties of temperature and pressure	**Inquiry Questions:** 1. How do people use the gas laws to represent, analyze, and communicate relationships in chemical systems and chemical interactions? **Relevance and Application:** 1. An exact proportion of gases is needed in many chemical reactions. For example, scuba tanks are filled with a set mixture of oxygen and nitrogen. 2. Nature produces gases that can be studied and analyzed, such as volcanic gases. 3. Human-managed systems such as wastewater treatment plants produce gases that can be recycled and converted into useable resources, such as the reformation of methane gas into hydrogen gas. **Nature of Discipline:** 1. Employ data-collection technology to gather, view, analyze, and interpret data about the properties of gases. 2. Ask testable questions about the nature of gases, and use an inquiry approach to investigate these.

Content Area: Science - Chemistry

Standard: 1. Physical Science

Valwood Graduates:

Apply an understanding of atomic and molecular structure to explain the properties of matter, and predict outcomes of chemical and nuclear reactions

GRADE LEVEL EXPECTATION

Concepts and skills students master:

4. The rate (speed) of a reaction depends on a variety of factors. Equilibrium is a dynamic process in which the forward rate of a reaction is the same as the reverse rate of a reaction, and the concentrations of reactants and products no longer change

Evidence Outcomes	**21st Century Skills and Readiness Competencies**
Students can: a. Explain the concept of "rate of reaction" and the factors that affect the rate b. Define the energy of activation and use it to explain the role of catalysts in a chemical reaction c. Explain the concept of dynamic equilibrium in both physical and chemical systems d. Extension: Write the equilibrium expression for a given reaction and solve for concentrations of substances and/or the equilibrium constant e. Extension: Use Le Chatelier's Principle to predict shifts in the concentrations of substances when a system at equilibrium is disturbed, and perform experiments testing these predictions	**Inquiry Question:** 1. How do people use the equilibrium model of chemical interactions to represent, analyze, and communicate structure and relationships in chemical systems and chemical interactions? **Relevance and Application:** 1. Environmental scientists can apply the understanding of chemical equilibria to environmental systems that show similar equilibrium properties. 2. Pressure, temperature, and concentration need to be taken into consideration in everyday examples of chemical reactions: for example, altitude affects the amount of leavening needed in baking and the amount of time needed to cook pasta. **Nature of Discipline:** 1. Ask testable questions about the nature of equilibrium and use an inquiry approach to investigate these questions.

Content Area: Science - Chemistry

Standard: 1. Physical Science

Valwood Graduates:

Engage in scientific inquiry by asking or responding to scientifically oriented questions, collecting and analyzing data, giving priority to evidence, formulating explanations based on evidence, connecting explanations to scientific knowledge, and communicating and justifying explanations

GRADE LEVEL EXPECTATION

Concepts and skills students master:

5. Scientists ask questions and state hypotheses using prior knowledge to help design and guide scientific investigations, using appropriate technology and safe laboratory practices

Evidence Outcomes	**21st Century Skills and Readiness Competencies**
Students can: a. Formulate testable hypotheses based on observed phenomena and prior knowledge b. Design and conduct an experiment to test a hypothesis, identifying the independent and dependent variables, and using appropriate equipment and technology to collect data c. Identify and use appropriate safe practices. d. Identify major sources of error or uncertainty and how they can be minimized e. Calculate percent error and report results using correct significant figures f. Write a conclusion linking results to the hypothesis	**Inquiry Questions:** 1. What types of questions and hypotheses can be answered by science? 2. What elements of design are critical in conducting a scientific investigation? 3. How can we ensure that scientific investigations are both safe and consistent with standard scientific practice? 4. How do we identify sources of error and quantify their impact on data? 5. How do we know if the conclusions of a scientific investigation are valid?
	Relevance and Application: 1. A scientific approach to answering a question requires formulating a testable hypothesis. 2. Questions about which a testable hypothesis cannot be formulated are not amenable to evaluation by the scientific method. 3. Safe practices in the lab extend to safe practices in the workplace.
	Nature of Discipline: 1. The scientific method involves formulating a hypothesis, designing experiments to test the hypothesis, and evaluating the data to determine if the results support the hypothesis.

Content Area: Science - Chemistry

Standard: 1. Physical Science

Valwood Graduates:

Engage in scientific inquiry by asking or responding to scientifically oriented questions, collecting and analyzing data, giving priority to evidence, formulating explanations based on evidence, connecting explanations to scientific knowledge, and communicating and justifying explanations

GRADE LEVEL EXPECTATION

Concepts and skills students master:

6. Scientists use the tools of math to solve problems, analyze data, and evaluate the validity of results

Evidence Outcomes	**21st Century Skills and Readiness Competencies**
Students can: a. Calculate quantities (such as density and specific heat) using the correct number of significant figures b. Identify when error has been introduced into a scientific investigation because certain variables are not controlled or more than one variable is changed c. Distinguish between error, uncertainty, and mistakes d. Calculate percent error e. Differentiate between accuracy and precision f. Use and convert between fundamental metric units	**Inquiry Questions:** 1. How do we identify sources of error and quantify their impact on data? 2. How accurately and precisely can a quantity be measured?
	Relevance and Application: 1. Being able to identify sources of variability is critical to deciding if an observation, such as an increase in the number of tornadoes in a given season, represents an actual change or is merely the result of natural fluctuation. 2. Incorrect conversion of English to metric units resulted in the failure of a NASA satellite.
	Nature of Discipline: 1. Math is a central tool of science.

Content Area: Science - Chemistry

Standard: 1. Physical Science

Valwood Graduates:

Apply an understanding of atomic and molecular structure to explain the properties of matter, and predict outcomes of chemical and nuclear reactions

GRADE LEVEL / COURSE EXPECTATION

Concepts and skills students master:

7. Matter can neither be created nor destroyed.
   The mole concept allows chemists to link the atomic world with the macroscopic world through the use of the periodic table. Stoichiometric relationships are used to determine "how much is needed" and "how much can be produced" in chemical reactions

Evidence Outcomes	**21st Century Skills and Readiness Competencies**
Students can: a. Explain the mole concept b. Use mole ratios in a balanced chemical equation to determine stoichiometric relationships of reactants and products c. Balance chemical equations to illustrate mole ratios and conservation of mass in a chemical reaction d. Calculate the mass and volume relationships of substances with emphasis on the mole concept, including percent composition, empirical formulas, limiting reactants and percent yield e. Calculate the empirical formula and molecular formula of a substance from experimental data f. Recognize and apply a variety of empirical methods for determining molar mass	**Inquiry Questions:** 1. How do we know how much of something we have? 2. How do we know how much we need for a reaction and how much we will produce? 3. How do we demonstrate that mass is conserved in a chemical reaction? **Relevance and Application:** 1. The mole concept allows scientists to determine how many essentially invisible particles (individual atoms or molecules) are present by weighing rather than counting, just as jelly beans are sold by the pound rather than by the number of jelly beans. 2. Stoichiometric calculations allow a scientist to determine how much reactant is necessary to produce a desired amount of product. **Nature of Discipline:** 1. Use an inquiry approach to determine the empirical formula of a compound.

Content Area: Science - Chemistry

Standard: 1. Physical Science

Valwood Graduates:

Apply an understanding of atomic and molecular structure to explain the properties of matter, and predict outcomes of chemical and nuclear reactions

GRADE LEVEL EXPECTATION

Concepts and skills students master:

8. Chemical reactions occur all around us and may either release or consume energy. A large number of reactions involve the transfer of either electrons or hydrogen ions

Evidence Outcomes	**21st Century Skills and Readiness Competencies**
Students can: a. Determine chemical formulas and names of ionic compounds and covalent molecules b. Name substances given IUPAC formulas c. Describe and predict the products for different types of reactions:synthesis, decomposition, single replacement, double replacement, and combustion d. Represent ionic and molecular species present in chemicals u sing a chemical equation e. Balance chemical equations to illustrate mole ratios and conservation of mass in a chemical reaction f. Define and compare concepts of acids and bases according t o Arrhenius and Bronsted-Lowry models g. Perform a neutralization reaction between acidic and basic substances h. Extension: Assign oxidation numbers to identify what is oxidized and what is reduced in an oxidation-reduction reaction **i.** Extension: Write oxidation and reduction half-reactions for an oxidation-reduction process	**Inquiry Questions:** 1. How do people identify and name substances? 2. How do people use the chemical equation to represent, analyze, and communicate relationships in chemical systems and chemical interactions? 3. How do we know how much of something we have, and how do we demonstrate that the amount of something is conserved? **Relevance and Application:** 1. Products formed in different types of reactions are useful to people. For example, the decomposition of sodium azide is used to inflate air bags. 2. Chemical processes can have both negative and positive environmental effects. For example, sulfur trioxide, a waste product from coal burning plants and a smog causing pollutant, can be removed by combining it with magnesium oxide. 3. Batteries and solar cells generate electricity by means of oxidation-reduction reactions. **Nature of Discipline:** 1. Describe and predict products for different types of reactions, such as combustion. 2. Use an inquiry approach to test predictions about chemical reactions.

Content Area: Science - Chemistry

Standard: 1. Physical Science

Valwood Graduates:

Apply an understanding of atomic and molecular structure to explain the properties of matter, and predict outcomes of chemical and nuclear reactions

GRADE LEVEL EXPECTATION

Concepts and skills students master:

9. Observed properties such as light emission and absorption and chemical reactivity can be related to electron configuration and nuclear charge

Evidence Outcomes	**21st Century Skills and Readiness Competencies**
Students can: a. Explain what atomic phenomena cause light emission and absorption b. Describe the evidence for the existence of atomic orbitals, electron configuration and electron energy levels c. Describe the periodic relationships of elements based on the following properties: atomic radii, ionization energies, electronegativity, and oxidation states d. Describe the key regions of electromagnetic radiation and how their properties arise from frequency and wavelength of the radiation e. Explain why light can be thought of as a wave or as a particle f. Extension: Use the relationship $c = \lambda v$ to calculate wavelength and frequency g. Extension: Use the relationship $E = hv$ to demonstrate why higher frequency correlates to higher energy.	**Inquiry Questions:** 1. How does the location of an element on the periodic table relate to the element's reactivity? 2. What is happening inside an atom when light is emitted or absorbed? 3. How does a combination of effective nuclear charge and electron shielding lead to an observed first ionization energy? **Relevance and Application:** 1. The color of gas discharge tubes is due to electrons releasing energy as they drop from a higher energy orbital to a lower one. 2. Whether a specific reaction between elements will take place can be predicted by examining the elements' positions on the periodic table. 3. The polarity of a bond, and therefore the predominant intermolecular forces, can be predicted by examining the constituents' relative positions on the periodic table. **Nature of Discipline:** 1. Identify the strengths and weaknesses of a model which represents complex natural phenomena.

Content Area: Science - Chemistry

Standard: 1. Physical Science

Valwood Graduates:

Apply an understanding of atomic and molecular structure to explain the properties of matter, and predict outcomes of chemical and nuclear reactions

GRADE LEVEL EXPECTATION: Chemistry

Concepts and skills students master:

10. Solutions need to be clearly described according to the substances and their amounts, including the interactions of the substances in a solution

Evidence Outcomes	**21st Century Skills and Readiness Competencies**
Students can: a. Describe types of solutions and factors affecting solubility of solutes in solvents b. Calculate the concentration of solutions using the concept of molarity c. Describe and show calculations for the preparation of a molar solution from a solid solute d. Describe and show calculations for the preparation of a molar solution by dilution of a more concentrated stock solution e. Describe and show calculations for determining the mass percent of a substance in solution f. Describe the nature of the pH scale, relating the values to acidic, basic, and neutral solutions g. Perform calculations with pH and $[H^+]$ h. Explain how a buffer solution resists changes in pH	**Inquiry Questions:** 1. What substances are contained in a solution? 2. Why does a solution have specific, unique properties? 3. How does the pH of a solution affect its properties? **Relevance and Application:** 1. Almost all liquid phase materials we encounter--such as blood, cell interiors, environmental systems and oceans—are solutions. 2. Concentrations of solutions affect the quantity of reactions. 3. Changing the pH of a stable ecosystem can have devastating effects. **Nature of Discipline:** 1. Clearly identify the parameters of an experimental system. 2. Ask testable questions about the concentrations of substances in solution, and use an inquiry approach to investigate these questions.

Content Area: Science - Chemistry

Standard: 1. Physical Science

Valwood Graduates:

Apply an understanding of atomic and molecular structure to explain the properties of matter, and predict outcomes of chemical and nuclear reactions

GRADE LEVEL EXPECTATION

Concepts and skills students master:

11. Temperature of a sample is related to the kinetic energy of the particles in the sample. Heat flows from a warmer object to a cooler object, and heat loss by a system equals heat gain by the surrounding (and vice versa)

Evidence Outcomes	**21st Century Skills and Readiness Competencies**
Students can: a. Identify and describe different forms of energy and their transformations b. Explain what it means when scientists say "the energy of the universe is constant" (First Law of Thermodynamics) c. Use kinetic molecular theory to describe the motion of molecules and its relationship to temperature and kinetic energy d. Use calorimetry to calculate the specific heat of a substance and the amount of heat change in a chemical reaction e. Classify reactions and phase changes as endothermic or exothermic f. Calculate the amount of heat lost or gained due to a phase change of a substance g. Determine the direction and amount of heat change for phase changes and chemical reactions h. Explain how all spontaneous processes are accompanied by an increase in the entropy of the universe (Second Law of Thermodynamics) i. Perform calculations using Gibbs free energy equation. j. Extension: Calculate enthalpy change in a chemical reaction using Hess's Law k. Extension: Calculate the heat of reaction using bond energies and heats of formation	**Inquiry Questions:** 1. What is heat, and how does it affect the way molecules interact? 2. What is the relationship between temperature and the heat change in a chemical or physical change? **Relevance and Application:** 1. Energy occurs in different forms and is necessary to do work and cause change. 2. Chemical reactions occur all around us and may either release or absorb energy. **Nature of Discipline:** 1. Identify the strengths and weaknesses of a model which represents complex natural phenomenon. 2. Employ data-collection technology to gather, view, analyze and interpret data about chemical and physical properties of different compounds. 3. Use an inquiry approach to test predictions regarding heat changes in chemical reactions.