Chemistry II Content Guidelines (3102)

SCED Description: CHEMISTRY—ADVANCED STUDIES Usually taken after a comprehensive initial study of chemistry, Chemistry—Advanced Studies courses cover chemical properties and interactions in more detail. Advanced chemistry topics include organic chemistry, thermodynamics, electrochemistry, macromolecules, kinetic theory, and nuclear chemistry.

Prerequisite: Chemistry I (3101)

The purpose of the Chemistry II is to provide students an in depth exploration of Chemistry I concepts. The content guidelines were developed to reflect the advanced nature of the course yet allow flexibility for division to choose topics that relate to student interest, make content relevant to the student population, and to connect with current issues or needs in the community.

# Scientific and Engineering Practices

Engaging in the practices of science and engineering helps students understand how scientific knowledge develops; such direct involvement gives them an appreciation of the many ways to investigate, model, and explain the world. These scientific and engineering practices include the use of scientific skills and processes to explore the content of science as outlined in the *Science Standards of Learning*. The engineering design practices are the application of science content to solve a problem or design an object, tool, process, or system. These scientific and engineering practices are critical to science instruction and are to be embedded throughout the year.

**CH.1 The student will demonstrate an understanding of scientific and engineering practices by**

1. **asking questions and defining problems**

* **ask questions that arise from careful observation of phenomena, examination of a model or theory, unexpected results, and/or to seek additional information**
* **determine which questions can be investigated within the scope of the school laboratory**
* **make hypotheses that specify what happens to a dependent variable when an independent variable is manipulated**
* **generate hypotheses based on research and scientific principles**
* **define design problems that involve the development of a process or system with interacting components, criteria and constraints**

1. **planning and carrying out investigations**
   * **individually and collaboratively plan and conduct observational and experimental investigations**

* **plan and conduct investigations or test design solutions in a safe manner, including planning for response to emergency situations**
* **select and use appropriate tools and technology to collect, record, analyze, and evaluate data**

1. **interpreting, analyzing and evaluating data**

* **record and present data in an organized format that communicates relationships and quantities in appropriate mathematical or algebraic forms**
* **use data in building and revising models, supporting explanations for phenomena, or testing solutions to problems**
* **solve problems using mathematical manipulations including the International System of Units (SI), scientific notation, derived units, significant digits, and dimensional analysis**
* **analyze data using tools, technologies, and/or models (e.g., computational, mathematical) to make valid and reliable scientific claims or determine an optimal design solution**
* **analyze data graphically and use graphs to make predictions**
* **differentiate between accuracy and precision of measurements**
* **consider limitations of data analysis when analyzing and interpreting data**
* **analyze data to optimize a design**

1. **constructing and critiquing conclusions and explanations**

* **construct and revise explanations based on valid and reliable evidence obtained from a variety of sources**
* **apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena or design solutions**
* **compare and evaluate competing arguments in light of currently accepted explanations and new scientific evidence**
* **construct arguments or counterarguments based on data and evidence**
* **differentiate between scientific hypothesis, theory, and law**

1. **developing and using models**

* **evaluate the merits and limitations of models**
* **develop, revise, and/or use models based on evidence to illustrate or predict relationships**
* **use models and simulations to visualize and explain the movement of particles, to represent chemical reactions, to formulate mathematical equations, and to interpret data sets**

1. **obtaining, evaluating, and communicating information**

* **compare, integrate, and evaluate sources of information presented in different media or formats to address a scientific question or solve a problem**
* **gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and credibility of each source**
* **communicate scientific and/or technical information about phenomena and/or a design process in multiple formats**

## Chemistry Content

CHEMII.2 The student will investigate and understand that atoms and molecules can be identified by their electron distribution and energy. Key ideas includes

1. atoms can be identified by their subatomic particles;
2. atomic theories describe the behavior of atoms as well as energy changes in the atom;
3. the electronic configuration provides a method for describing the distribution of electrons in an atom or ion;
4. the relationship between energy changes in the atom specific to the movement of electrons between energy levels results in the emission or absorption of quantum energy;
5. the periodic table shows patterns in electron structure and trends in atomic properties;
6. chemical formulas identify substances by their unique combination of atoms; and
7. macroscopic systems involve such large numbers of atoms that they require moles as a unit of comparison.

CHEMII.3 The student will investigate and understand that the chemical and physical properties of materials can be explained by the structure and arrangement of atoms, ions, or molecules and the forces between them. Key ideas include

1. atoms or ions bond based on electronegativity and electron interactions;
2. molecular compound arrangement of atoms are predicted using the Valence Shell Electron Pair Repulsion (VSEPR) theory;
3. hybridization describes the arrangement of electrons around the central atom.
4. Coulomb’s Law can be used to understand the strength of interactions between cations and ions; and
5. metallic bonding can be represented as an array of positive metal ions surrounded by delocalized electrons.

CHEMII.4 The student will investigate and understand that the relative orderliness of the arrangement of particles, their relative freedom of motion, and the nature of the strength of the interactions determine states of matter. Key ideas include

1. matter exists in three states: solids, liquids, and gases;
2. many properties of liquids and solids are determined by the strengths and types if intermolecular bonds present;
3. the kinetic molecular theory relates the macroscopic properties of gases to the motions of the particles in the gas;
4. gas properties are explained macroscopically using the relationships among pressure, volume, temperature, moles, and gas contents;
5. solutions can be solids, liquids, or gases;
6. molar relationships determine a solutions concentration; and
7. interactions between the intermolecular forces influence the solubility and separation of solutions.

CHEMII.5 The student will investigate and understand that atoms are conserved in chemical reactions. Key ideas include:

1. chemical processes can be represented symbolically by balanced equations to include molecular, ionic, and net ionic representations;
2. matter interactions can be identified as oxidation-reduction reactions, such as synthesis, combustion, decomposition and single replacement and non redox reactions such as neutralization and double replacement reactions.
3. all chemical reactions fall into two categories reduction- oxidation or not reduction-reduction, these include neutralization, synthesis, decomposition, combustion, and single and double replacement reactions;
4. stoichiometry is used calculate product amounts by using known reactant amounts (and vice versa)
5. titrations may be used to determine the concentration of an analyte in a solution.

CHEMII.6 The student will investigate and understand that rates in a chemical reaction are observable and measureable. Key ideas include

1. factors including the concentration of the reactants, temperature, catalysts, surface area, and other environmental factors determine the rate at which chemical changes occur;
2. collision theory describes the criteria needed to be met for a reaction to occur;
3. the kinetics of a chemical reaction is defined as the rate at which an amount of reactant is converted to products per unit time;
4. the rate law expresses the rate of reaction as proportional to the concentration of each reactant raised to a power; and
5. a reaction mechanism consists of a series of proposed elementary reactions that occur in a sequence and align to the overall reaction.

CHEMII.7 The student will investigate and understand that many observable processes are reversible. Key ideas include

1. many reactions are dynamic with reactants and products being formed simultaneously;
2. equilibrium is reached when the net concentration of reactants or produces does not change within a dynamic system;
3. the reaction quotient Q describes the rate of relative concentrations of reaction species at any given time;
4. equilibrium constants can be determined from experimental measurements of the concentrations or partial pressures of the reactants and produces at equilibrium; and
5. the response of a system when stresses are introduced to the system can be predicted using Le Chalelier’s principle..

CHEMII.8 The student will investigate and understand equilibrium concentrations of a neutralization reactions is related to the strength of the acids and bases involved. Key ideas include

1. acids and bases can be classified using Arrhenius or Bronsted Lowry definitions.
2. the pH and pOH can be calculated for acids and bases;
3. strong acids and bases react completely to form a neutral solution. and the excess of either reactant can be used to determine final pH or pOH;
4. an equilibrium is established between weak acids and weak bases and un-ionized acid/base and its conjugate base/acid;
5. buffers resist change to pH when small amounts of acid or based are introduced and are important for biological systems; and
6. acid-base reactions are carried out under controlled conditions in a titration.

CHEM.9 Students will investigate and understand a specific field in chemistry. Topics, such as these listed, may include.

1. Thermochemistry (to include enthalpy, entropy, bond energy, Hess’s Law, spontaneity, and thermal equilibrium)
2. Organic Chemistry (to include nomenclature, bonding molecular structure and reactivity, reaction mechanisms, and current spectroscopic techniques)
3. Electrochemistry (to include galvanic and electrolytic cells, cell potential, and free energy)
4. Biochemistry (to include macromolecules, biochemical processes, and metabolic reactions)
5. Nuclear Chemistry (to include changes of nuclear composition and energy changes in the processes of fission, fusion, and radioactive decay)