Chemistry for the Technologies

Course Competencies/Objectives with Activities and Labs

Course Code: 3236

Course Description

Chemistry for the Technologies is designed to be both academically rigorous and realistic for students pursing technical careers and for students planning to continue their education at the technical or collegiate level. The emphasis will be on the technological aspects of chemistry with laboratory experiences comprising most of the course work. The focus is on the understanding and application of chemical skills as they relate to current industry practice. Instructors are encouraged to work with occupational instructors and local businesses and industries to incorporate career and technology applications of chemistry. Investigative, hands-on lab activities that address the high school inquiry standards are an integral part of this course.

Science Prerequisite: Physical science or integrated science.
Mathematics Prerequisite: Mathematics for the Technologies 1 and 2 or Algebra 1.

Note on Safety Requirement

A required safety program must be implemented for students prior to initial lab activity. Safety should be addressed throughout the course in every unit of study.

Key to Notes in S.C. Standards

- H = History of Science
- N = Nature of Science
- P = Science in Social and Personal Perspectives
- T - Technology

Key to Notes in Competencies

- A (1) listed after a competency indicates that it can be addressed in laboratory exercises.

Digitized by South Carolina State Library

- A (2) listed after a competency indicates that the use of computer and/or calculator interface-based laboratory work is appropriate.
- A (3) listed after a competency indicates that computer software is available for enhancement.

Key to Chemistry for the Technologies Lab Module Numbers

Module 1	Laboratory Safety and Techniques
Module 2	Training Manual/new Employee Orientation
Module 3	Measurement and Data Analysis
Module 4	hazardous Waste and MSDS
Module 5	Metals: Recycling Copper
Module 6	Spectophotometry and Chromatography
Module 7	Gases, Solids, and Liquids
Module 8	Solutions and Dilutions
Module 9	Organic Chemistry
Module 10	Fiber Industries
Module 11	Synthesis of Aspirin
Module 12	Analysis of Aspirin
Module 13	Nuclear Chemistry
Module 14	Electrochemistry
Module 15	Gas Chromatography

The Chemistry for the Technologies Lab Modules are a product of the South Carolina Department of Education.

Digitized by South Carolina State Library

Topic: Chemical Safety

S.C. Standard	Performance Objectives (Competencies)	Suggested Activities
Inquiry (safety) **Chemistry:** **IV.C.1.c.** Explain the sources and environmental effects of some inorganic and organic toxic substances, such as heavy metals and PCBs. (P)	*Note: These activities should be addressed throughout the course in every unit of study.* • Include safety hazards as a part of every chemical operation. (1) • Define, interpret, and apply classifications of flammability, toxicity, health, and reactivity. • Be able to read and interpret the Material Safety Data Sheet (MSDS) for a particular material. (3) • Wear or use personal protection equipment (gloves, hoods, goggles, etc.). (1) • Locate and operate emergency equipment (e.g., shower, eyewash, fire alarm, fire extinguisher, fire blanket). (1) • Be able to take appropriate measures should an accident or injury occur. • Dispose of waste in a safe and environmentally correct manner. (1)	• American Chemical Society (ACS) Safety video; Safety contract; Laboratory Safety and Techniques (Module 1); Hazardous Waste and MSDS (Module 4).

Digitized by South Carolina State Library

Topic: Operational Safety and Scientific Measurement

S.C. Standard	Performance Objectives (Competencies)	Suggested Activities
Inquiry	• Demonstrate the relationship between product quality, reproducibility, and accuracy/precision in measurement. (1, 2, 3) ▪ Measure pressure, temperature, volume, and weight in SI and English units as appropriate for specific industrial uses. ▪ Record measurements to one estimated digit. ▪ Determine the error and uncertainty in measurements.	• Measurement activities. • Measurement and Data Analysis (Module 3).
	• Perform conversions of units within the SI system, using the prefixes kilo-, deci-, centi-, milli-, micro-, and nano-. Perform conversions within the English system. Industry uses both systems. Perform conversions between the SI and English systems. Use the factor label method or dimensional analysis in the conversion of units.	• Measurement and Data Analysis (Module 3).
	• Interpret graphs, charts, and tables. (1, 2, 3) ▪ Construct graphs, charts, and tables from data. ▪ Analyze and make predictions from graphs, charts, and tables.	• Measurement and Data Analysis (Module 3).
	• Demonstrate the appropriate techniques for the use of chemical lab equipment. (1)	• Measurement and Data Analysis (Module 3).
	• Apply mathematical statistics (standard deviation, mean, linear regression). *(Optional)*	• Measurement and Data Analysis (Module 3).

Digitized by South Carolina State Library

Topic: Chemical Structure and Chemical Behavior

S.C. Standard	Performance Objectives (Competencies)	Suggested Activities

Inquiry
 	
Chemistry:
IV.B.2.b. Explain the arrangement of elements with a group on the periodic table based on similar physical and chemical properties.
 	
IV.B.2.c. Explain that property trends on the periodic table are a function of the elements' atomic structures.
 	
IV.B.3.d. Predict the ratio by which the representative elements combine to form ionic compounds, expressing that ratio in a chemical formula.
	• Interpret the periodic table. (3)
	  ▪ Classify elements as metals, nonmetals and metalloids. (1)
	  ▪ Identify chemical and physical properties of elements according to their location on the periodic table.
	
	• Use electron dot formulas to demonstrate ionic and covalent bonding (octet rule).
	
	• Write names and formulas for ionic and covalent compounds. (3)
		• Properties of metals versus nonmetals.
		• Training Manual/New Employee Orientation (Module 2).
		
		• Metals: Recycling Copper (Module 5)
		
		• Metals: Recycling Copper (Module 5)

Digitized by South Carolina State Library

Topic: Chemical Equations and Stoichiometry

S.C. Standard	Performance Objectives (Competencies)	Suggested Activities
Inquiry **Chemistry:** **IV.B.4.e.** Identify factors that affect the rates at which substances dissolve. **IV.B.4.f.** Compare the amount of solute and solvent in concentrated and dilute mixtures. **IV.C.2.b.** Recognize balanced chemical equations. **IV.C.2.d.** Conclude from experimental evidence that mass is neither created nor destroyed based on mass measurements. (N) **IV.C.4.a.** Describe how reaction rates are a function of the collisions among particles. **IV.C.4.b.** Analyze the effects of temperature, particle size, stirring, concentration, and catalysts on reaction	• Differentiate and balance the various types of equations given the reactants and products (synthesis, double displacement, single displacement, decomposition, combustion). • Predict products for neutralization and combustion reactions. (1) • Calculate mole/weight (mole/mass) relationships. (1) • Calculate percent composition. • Calculate the weight proportions of reactants and products from balanced equations. (1) • Analyze the limiting reagent for chemical reactions by calculation. (1) • Determine the percent yield and mass of excess of a reagent for chemical reactions. (1) • Perform a material balance (e.g., account for the weights of all reagents and solvents in a chemical process) either in lab or using simulated industrial data. (1)	• Types of reactions lab. • Metals: Recycling Copper (Module 5). • Metals: Recycling Copper (Module 5) • Mole lab. • Metals: Recycling Copper (Module 5). • Percent composition of gum. • Metals: Recycling Copper (Module 5). • Smores Lab • Metals: Recycling Copper (Module 5) • Metals: Recycling Copper (Module 5) • Gases, Solids, and Liquids (Module 7)

Digitized by South Carolina State Library

rates. **IV.C.4.c.** Apply reaction rate concepts to real-life applications such as food spoilage, storage of film and batteries, digestive aids, and catalytic converters. (P, T)	• Using density, calculate weight to volume and volume to weight. (1) • Assay product purity using simple analytical chemical procedures. (The instructor may want to wait until molarity has been covered before addressing this competency.) (1) • Conduct investigations to determine the effect of temperature, concentration, and catalysts on reaction rates. (1)	• Density Lab. • Measurement and Data Analysis (Module 3) • Synthesis of Aspirin (Module 11) • Analysis of Aspirin (Module 12). • Rates of reaction lab. • Gases, Solids, and Liquids (Module 7). • Organic Chemistry (Module 9).

Digitized by South Carolina State Library

Topic: Gases, Solids, and Liquids

S.C. Standard	Performance Objectives (Competencies)	Suggested Activities
Inquiry **Physics:** **IV.B.3.a.** Predict and measure the effects of varying the temperature, pressure, and volume of gases. (N) **IV.B.3.b.** Assess particle motion and distance as they relate to temperature and phase changes. **IV.B.3.c.** Assess the hazards of handling and storing pressurized gases. (P, T)	• Calculate gas law problems concerning changes in pressure, volume, or temperature. (1, 3) • Use the Kinetic Molecular Theory (KMT) as a model to explain gas behaviors and the significance of the absolute temperature scale. (3) • Define boiling point and explain how it varies with changes in pressure. (1) • Predict changes in viscosity due to changes in temperature.	• Charles' Law lab. • Gases, Solids, and Liquids (Module 7). • Boyle's Law lab. • Gases. Solids, and Liquids (Module 7). • Demonstration: boiling water in a syringe. • Gases, Solids, and Liquids (Module 7). • Organic Chemistry (Module 9)

Digitized by South Carolina State Library

Topic: Solutions

S.C. Standard	Performance Objectives (Competencies)	Suggested Activities
Inquiry **Chemistry:** **IV.B.4.c.** Investigate how solubility varies among different solutes and for the same solute at different temperatures. **IV.B.4.d.** Analyze the behavior of polar and nonpolar substances in forming solutions. **IV.B.4.e.** Identify factors that affect the rates at which substances dissolve. **IV.B.4.f.** Compare the amount of solute and solvent in concentrated and dilute mixtures.	• Define solubility, saturated, unsaturated, supersaturated, solute, and solvent. • Compare solubility of various substances in different solvents (polar and nonpolar solvents and organic and inorganic substances). (1) • Describe the concentrations of solutions by molarity and percent weight (mass). • Prepare solutions and dilute to different concentrations. (1) • Use titration to determine product concentrations. (1, 2) • Identify practical uses for the colligative properties of solutions (e.g., industrial uses of brine for cooling). (1) • Describe and perform these separation processes: ▪ Distillation. (1)	• Saturation lab. • Solutions and Dilutions (Module 8). • Spectophotometry and Chromatography (Module 6). • Fiber Industries (Module 10). • Analysis of Aspirin (Module 12) • Solutions and Dilutions (Module 8). • Solutions and Dilutions (Module 8). • Demonstration: Tyndall Effect • Solutions and Dilutions (Module 8). • Gases, Solids, and Liquids (Module 7). • Gases, Solids, and Liquids (Module 7) • Synthesis of Aspirin (Module 11)

Digitized by South Carolina State Library

	▪ Crystallization. (1) ▪ Filtration. ▪ Paper chromatography. (1) ▪ Centrifugation, extraction, and gas chromatography should be performed if equipment is available. • Define and give the properties of colloids. • Identify types of colloidal suspensions and give examples.	• Spectophotometry and Chromatography (Module 6); Fiber Industries (Module 10); Synthesis of Aspirin (Module 11). • Spectophotometry and Chromatography (Module 6). • Spectophotometry and Chromatography (Module 6); Synthesis of Aspirin (Module 11); Gas Chromatography (Module 15). • Gases, Solids, and Liquids (Module 7). • Gases, Solids, and Liquids (Module 7).

Digitized by South Carolina State Library

Topic: Acids, Bases, and Salts

S.C. Standard	Performance Objectives (Competencies)	Suggested Activities
Inquiry **Chemistry:** **IV.C.3.a.1.** Identify the physical characteristics of acids and bases.	• Classify substances as acids, bases, or salts. (1)	• Properties of acids and bases; Solutions and Dilutions (Module8).
IV.C.3.a.2. Identify acids and bases in terms of their pH.	• Identify acids and bases as strong or weak.	• Solutions and Dilutions (Module8). • Solutions and Dilutions (Module 8).
IV.C.3.a.3. Describe neutralization reactions.	• Write names and formulas for common acids and bases. • Identify and predict products of important acid and base reactions: ▪ Neutralization. ▪ Reactions with metals.	• Metals: Recycling Copper (Module 5); Solutions and Dilutions (Module 8); Synthesis of Aspirin (Module 11).
IV.C.3.a.4. Explain how acid rain is formed and discuss its effects on the environment. (P)		• Solutions and Dilutions (Module 8). • Solutions and Dilutions (Module 8).
IV.C.3.a.5. Evaluate the role pH plays in the development of consumer products. (N, P)	• Define pH and relate the definition to the ionization of water. • Use the log and exponent keys EE and EXP on a calculator to perform pH calculations. (2)	• Solutions and Dilutions (Module 8); Analysis of Aspirin (Module 12). • Solutions and Dilutions (Module 8); Analysis of Aspirin (Module 12).
IV.C.3.a.6. Analyze the color changes of some common indicators to distinguish among the ranges of acidic, basic, and neutral solutions.	• Calibrate a pH meter and use it to measure pH. (1, 2) • Compare and contrast pH as determined by pH meters and indicator paper. (1)	• Solutions and Dilutions (Module 8); Analysis of Aspirin (Module 12).

Digitized by South Carolina State Library

	• Titration
	  ▪ Perform a strong acid/strong base titration to identify the equivalence point by color change.
	  ▪ Analyze the titration curve of a strong acid/strong base reaction and compare the sensitivity of pH change to volume of titrant added. (1, 2, 3)
	
	• Identify and use appropriate safety measures when dealing with acids and bases.
		• Throughout Course

Digitized by South Carolina State Library

Topic: Organic Chemistry (Optional)

S.C. Standard	Performance Objectives (Competencies)	Suggested Activities
Inquiry **Chemistry:** **IV.B.6.a.** Analyze how carbon atoms bond to one another in a variety of structures. **IV.B.6.b.** Describe polymers as molecules bonded together. **IV.B.6.c.** Determine uses of aromatic compounds and polymers in everyday life. (P) **IV.B.6.d.** Explore, investigate, and list some common uses of petroleum products, including manufacturing and medical applications.	• Name and draw structural formulas of alkanes, alkenes, and alkynes. • Write structural formulas for isomers. • Identify functional groups and use them to classify organic compounds. • Classify organic reactions as addition, substitution, elimination, or condensation. (1) • Differentiate between addition and condensation polymerization. • Name and write structural formulas for the benzene rings and cyclohexanes.	• Slime; Organic Chemistry (Module 9). • Nylon; Organic Chemistry (Module 9). • Polymer lab module; Organic Chemistry (Module 9). • Organic Chemistry (Module 9). • Organic Chemistry (Module 9). • Slime; Organic Chemistry (Module 9).

Digitized by South Carolina State Library

Topic: Electrochemistry

S.C. Standard	Performance Objectives (Competencies)	Suggested Activities
Inquiry **Chemistry:** **IV.C.1.a.** Explain the process of rusting in terms of electron transfer and debate the economic impact of rusting.	• Define oxidation, reduction, anode, cathode, and electrolyte. • Diagram, construct, and label a voltaic cell. (1) • Use standard reduction potentials to calculate voltage of standard voltaic cells. • Construct an electrolysis cell for electroplating. (1) • Describe the production of metals from ore by electrolysis (Al and Na). • Describe methods to prevent corrosion (paint or coating alloys, sacrificial anode). (1)	• Fiber Industries (Module 10); Electrochemistry (Module 14). • Electrochemistry (Module 14). • Electrochemistry (Module 14). • Electrochemistry (Module 14). • Electrochemistry (Module 14). • Electrochemistry (Module 14).

Digitized by South Carolina State Library

Topic: Nuclear Chemistry

S.C. Standard	Performance Objectives (Competencies)	Suggested Activities and Inquiry-Based Labs
Chemistry: **IV.A.3.b.** Contrast the energy released by nuclear reactions to that released by chemical reactions. **IV.A.4.a.** Explain that unstable isotopes undergo spontaneous nuclear decay, emitting energy or particles and energy. **IV.A.4.b.** Apply the predictable rate of nuclear decay to estimate the age of materials.	• Compare and contrast the energy released by chemical and nuclear reations. • compare and contrast, alpha, beta, and gamma radiation. • Describe modern day uses of radioactivity (medical and nonmedical applications). • Define hald life and describe the trend over time. • Apply the predictable rate of nuclear decay to estimate the age of materials.	• Nuclear (Module 13). • Nuclear (Module 13). • Nuclear (Module 13). • Nuclear (Module 13). • Nuclear (Module 13).

Digitized by South Carolina State Library