

# College Chemistry

## Curriculum

Vineland Public Schools  
Vineland, NJ  
2004

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## College Prep Chemistry Purpose and Goals

In today's society, the need for scientific literacy is imperative. As defined by the American Association for the Advancement of Science in the groundbreaking 1993 report, *Benchmarks for Scientific Literacy*, "In a culture increasingly pervaded by science, mathematics and technology, science literacy requires understandings and habits of mind that enable citizens to grasp what those enterprises are up to, to make some sense of how the natural and designed worlds work, to think critically and independently, to recognize and weigh alternative explanations of events and design trade-offs, and to deal sensibly with problems that involve evidence, numbers, patterns, logical arguments and uncertainties."

The curriculum of College Prep Chemistry is designed to provide the college bound non-science major with a basic understanding of the fundamental concepts of chemistry and its application to daily living. The infusion of career information and career awareness is included to aid students in making decisions for their future study.

Students will study matter and the changes it undergoes, specifically atomic theory, stoichiometry and qualitative analysis. Students will gain knowledge of specific scientific information and terminology, and develop the skills of observing, comparing and contrasting, questioning, studying and judging ideas and phenomena.

Laboratory experiments will result in students recording observations, collecting data, graphing and using this information to identify relationships and draw conclusions. Students will distinguish facts from hypotheses, theories and models. Students should use metric units in measurements and record lab experiences in a report using appropriate technical writing to convey their purpose and results. Students will demonstrate knowledge of safety rules which include wearing proper lab apparel, goggles and lab apron, using fire extinguishers and eye washes, and handling and disposing of chemicals properly.

In order to carry out the purpose of chemistry education, the Vineland Public Schools Science Program focuses on the following goals, adapted from the Mission Statement and Goals of the Vineland Public Schools, the New Jersey Science Core Course Proficiencies, the New Jersey Science Core Curriculum Content Standards and the New Jersey Cross-Content Workplace Readiness Standards.

These goals are:

- 1) The students will be exposed to a variety of learning environments that are conducive to our multicultural society.
- 2) The students will increase their self-esteem and confidence in their knowledge and ability in chemistry.
- 3) The students will learn to value chemistry and will become aware of the use of chemistry in various careers and possible future vocations.
- 4) The students will understand and use chemical vocabulary and symbolic notation to represent and communicate ideas.
- 5) The students will use appropriate technology throughout the course including calculators and computers.

- 6) The students will collect, represent and interpret data in ways that enable them to make meaningful decisions and conclusions.
- 7) The students will use technical writing in lab reports as representative of the major source of communication between scientists.
- 8) The students will follow laboratory safety precautions and wear goggles and lab aprons when working in lab.
- 9) The students will demonstrate self-management skills when working on research projects and laboratory experiments.
- 10) The students will identify differences between subatomic particles, atoms and molecules and their relationship to atoms and molecules.
- 11) The students will gain an understanding of the organization of the periodic table as a tool for predicting properties and reactions.
- 12) The students will use their conceptual and procedural knowledge of matter, energy and chemical reactions in solving problems of daily living.
- 13) The students will investigate chemistry through hands on learning experience and determine sources of error and the precision and accuracy of measurement.
- 14) The students will develop and apply problem solving, decision making inquiry and communication skills.
- 15) The students will recognize that science and technology can respond to and generate changes in social/political conditions as demonstrated by the contributions of scientists.
- 16) The students should recognize that science uses technology to solve problems and that technical problems create a need for scientific knowledge, including its ability to influence the direction that science takes.
- 17) The students should integrate mathematics as a tool for problem solving in science and as a means of expressing and/or modeling scientific theories, including its use to determine and support conclusions.
- 18) The students should be able to describe atomic structure and its relationship to the nature of bonding.
- 19) The students should be able to demonstrate an understanding of a chemical reaction.
- 20) The students will be able to identify various forms of energy and explain how they are transformed or transferred.

New Jersey Core Curriculum Content Science Standards and their Indicators

**STANDARD 5.1 (SCIENTIFIC PROCESSES) ALL STUDENTS WILL DEVELOP PROBLEM-SOLVING, DECISION-MAKING AND INQUIRY SKILLS, REFLECTED BY FORMULATING USABLE QUESTIONS AND HYPOTHESES, PLANNING EXPERIMENTS, CONDUCTING SYSTEMATIC OBSERVATIONS, INTERPRETING AND ANALYZING DATA, DRAWING CONCLUSIONS, AND COMMUNICATING RESULTS.**

**Building upon knowledge and skills gained in preceding grades, by the end of Grade 12, students will:**

**A. Habits of Mind**

1. When making decisions, evaluate conclusions, weigh evidence, and recognize that arguments may not have equal merit.
2. Assess the risks and benefits associated with alternative solutions.
3. Engage in collaboration, peer review, and accurate reporting of findings.
4. Explore cases that demonstrate the interdisciplinary nature of the scientific enterprise.

**B. Inquiry and Problem Solving**

1. Select and use appropriate instrumentation to design and conduct investigations.
2. Show that experimental results can lead to new questions and further investigations.

**C. Safety**

1. Understand, evaluate and practice safe procedures for conducting science investigations.

**STANDARD 5.2 (SCIENCE AND SOCIETY) ALL STUDENTS WILL DEVELOP AN UNDERSTANDING OF HOW PEOPLE OF VARIOUS CULTURES HAVE CONTRIBUTED TO THE ADVANCEMENT OF SCIENCE AND TECHNOLOGY, AND HOW MAJOR DISCOVERIES AND EVENTS HAVE ADVANCED SCIENCE AND TECHNOLOGY.**

**Building upon knowledge and skills gained in preceding grades, by the end of Grade 12, students will:**

**A. Cultural Contributions**

1. Recognize the role of the scientific community in responding to changing social and political conditions and how scientific and technological achievement effect historical events.

**B. Historical Perspectives**

1. Examine the lives and contributions of important scientists who affected major breakthroughs in our understanding of the natural and designed world.
2. Discuss significant technological achievements in which science has played an important part as well as technological advances that have contributed directly to the advancement of scientific knowledge.
3. Describe the historical origin of important scientific developments such as atomic theory, genetics, plate tectonics, etc., showing how scientific theories develop, are tested, and can be replaced or modified in light of new information and improved investigative techniques.

**STANDARD 5.3 (MATHEMATICAL APPLICATIONS) ALL STUDENTS WILL INTEGRATE MATHEMATICS AS A TOOL FOR PROBLEM-SOLVING IN SCIENCE, AND AS A MEANS OF EXPRESSING AND/OR MODELING SCIENTIFIC THEORIES.**

**Building upon knowledge and skills gained in preceding grades, by the end of Grade 12, students will:**

**A. Numerical Operations**

1. Reinforce indicators from previous grade level.

**B. Geometry and Measurement**

1. When performing mathematical operations with measured quantities, express answers to reflect the degree of precision and accuracy of the input data.

**C. Patterns and Algebra**

1. Apply mathematical models that describe physical phenomena to predict real world events.

**D. Data Analysis and Probability**

1. Construct and interpret graphs of data to represent inverse and non-linear relationships, and statistical distributions.

**STANDARD 5.4 (NATURE AND PROCESS OF TECHNOLOGY) ALL STUDENTS WILL UNDERSTAND THE INTERRELATIONSHIPS BETWEEN SCIENCE AND TECHNOLOGY AND DEVELOP A CONCEPTUAL UNDERSTANDING OF THE NATURE AND PROCESS OF TECHNOLOGY.**

**Building upon knowledge and skills gained in preceding grades, by the end of Grade 12, students will:**

**A. Science and Technology**

1. Know that scientific inquiry is driven by the desire to understand the natural world and seeks to answer questions that may or may not directly influence humans, while technology is driven by the need to meet human needs and solve human problems.

**B. Nature of Technology**

1. Assess the impacts of introducing a new technology in terms of alternative solutions, costs, tradeoffs, risks, benefits and environmental impact.

### **C. Technological Design**

1. Plan, develop, and implement a proposal to solve an authentic, technological problem.

## **STANDARD 5.5 (CHARACTERISTICS OF LIFE) ALL STUDENTS WILL GAIN AN UNDERSTANDING OF THE STRUCTURE, CHARACTERISTICS, AND BASIC NEEDS OF ORGANISMS AND WILL INVESTIGATE THE DIVERSITY OF LIFE.**

**Building upon knowledge and skills gained in preceding grades, by the end of Grade 12, students will:**

### **A. Matter, Energy and Organization in Living Systems**

1. Relate the structure of molecules to their function in cellular structure and metabolism.
2. Explain how plants convert light energy to chemical energy.
3. Describe how plants produce substances high in energy content that become the primary source of energy for life.
4. Relate disease in humans and other organisms to infections or intrinsic failures of system.

### **B. Diversity and Biological Evolution**

1. Explain that through evolution the Earth's present species developed from earlier distinctly different species.
2. Explain how the theory of natural selection accounts for extinction as well as an increase in the proportion of individuals with advantageous characteristics within a species.

### **C. Reproduction and Heredity**

1. Describe how information is encoded and transmitted in genetic material.
2. Explain how genetic material can be altered by natural and/or artificial means; mutations and new gene combinations may have positive, negative, or no effect on organisms or species.
3. Assess the impact of current and emerging technologies on our understanding of inherited human characteristics.

## **STANDARD 5.6 (CHEMISTRY) ALL STUDENTS WILL GAIN AN UNDERSTANDING OF THE STRUCTURE AND BEHAVIOR OF MATTER.**

**Building upon knowledge and skills gained in preceding grades, by the end of Grade 12, students will:**

### **A. Structure and Properties of Matter**

1. Know that atoms are made of a positive nucleus surrounded by negative electrons and that the nucleus, a tiny fraction of the volume of an atom, is composed of protons and neutrons, each almost 2,000 times more massive than an electron.
2. Know that the number of protons in the nucleus defines the element.
3. Know that an atom's electron arrangement, particularly the outermost electrons, determines how the atom can interact with other atoms.
4. Explain that atoms form bonds (ionic and covalent) with other atoms by transferring or sharing electrons.
5. Explain how the Periodic Table of Elements reflects the relationship between the properties of elements and their atomic structure.
6. Know that many biological, chemical and physical phenomena can be explained by changes in the arrangement and motion of atoms and molecules.
7. Recognize that the properties of matter are related to the structure and arrangement of their molecules and atoms, such as in metallic and nonmetallic crystals and carbon compounds.
8. Know that different levels of energy of an atom are associated with different configurations of its electrons.

#### **B. Chemical Reactions**

1. Explain that the rate of reactions among atoms and molecules depends on how often they encounter one another and that the rate is affected by nature of reactants, concentration, pressure, temperature, and the presence of a catalyst.
2. Show that some changes in chemical bonds require a net input or net release of energy.

### **STANDARD 5.10 (ENVIRONMENTAL STUDIES) ALL STUDENTS WILL DEVELOP AN UNDERSTANDING OF THE ENVIRONMENT AS A SYSTEM OF INTERDEPENDENT COMPONENTS AFFECTED BY HUMAN ACTIVITY AND NATURAL PHENOMENA.**

**Building upon knowledge and skills gained in preceding grades, by the end of Grade 12, students will:**

#### **A. Natural Systems and Interactions**

1. Distinguish naturally occurring process from those believed to have been modified by human interaction or activity.
  - climate change
  - ozone production
  - erosion and deposition
  - threatened and endangered species

#### **B. Human Interactions and Impact**

1. Assess the impact of human activities on the cycling of matter and the flow of energy through ecosystems.
2. Use scientific, economic, and other data to assess environmental risks and benefits associated with societal activity.

New Jersey Cross-Content Workplace Readiness Standards

Standard 1:

All Students will Develop Career Planning and Workplace Readiness Skills

Standard 2:

All Students Will Use Information, Technology, and Other Tools

Standard 3:

All Students Will Use Critical Thinking, Decision Making and Problem-Solving Skills

Standard 4:

All Students Will Demonstrate Self-Management Skills.

Standard 5:

All Students Will Apply Safety Principles.

## Introduction to Chemistry

### A. Introduction

College Prep Chemistry begins with an introduction to the science of Chemistry and the fundamental concepts used by chemists. Basic mathematical concepts, problem solving and laboratory safety is presented. A brief history of chemistry will be reviewed. Students identify the basic terminology of chemistry, for example, compounds and elements.

### B. Student Outcomes/Objectives

The students will be able to:

- 1) Perform calculations on mathematical operations with significant figures used in measurement. (5.3) 12-B-1 WRS 2
- 2) Logically gather, order and interpret data through an appropriate use of measurement and tools. (5.3) 8-C-1 WRS 2
- 3) Use appropriate metric units to express measurements of length, mass, volume, temperature, density and specific heat. (5.3) 8-B-1
- 4) Interpret data using graphs, spreadsheets and data bases. (5.3) 12-D-1 WRS 2
- 5) Evaluate possible effects of measurement errors on calculations. (5.3) 12-B-1 WRS 3
- 6) Investigate the multicultural diversity of scientists who have made major contributions to the foundation of science. (5.2) 12-A-1
- 7) Recognize the cause and effect relationships between social/political needs and the field of science. (5.4) 12-B-1 WRS 3
- 8) Differentiate between pure substances, mixtures and compounds and elements. (5.6) 8-A-4
- 9) Cite examples of how technologies have been influenced by changes in our understanding of atomic theory from the early Greek models to the end of alchemy. (5.2) 12-B-1
- 10) Compare and contrast physical and chemical changes. (5.6) 8-B-1
- 11) Describe the Conversion and Conservation of Energy and Mass and how they are related. (5.6) 8-B-3
- 12) Observe required lab safety guidelines regarding attire, use of safety equipment, and the care of handling chemicals. (5.1) 12-C-1 WRS 4, 5
- 13) Explain how the behavior of matter under various common circumstances is dependent on its physical state: solid, liquid, gas or plasma. (5.6) 8-A-2
- 14) Practice problem solving skills through the use of dimensional analysis. (5.3) 12-C-1 WRS 3
- 15) Determine metals, nonmetals and metalloids by using the periodic table and list their characteristics. (5.6) 8-A-3
- 16) Calculate specific heat problems and use the appropriate terminology to describe them. (5.6) 8-B-2

17) Discuss various careers that use chemistry and the different branches of chemistry. (5.2) 12-B-2 WRS 1

### C. Learning Activities

- 1) Research project: Use the internet to research information on the elements
- 2) Project: Use the Merck Index and/or internet to research compounds
- 3) Use excel program to graph density
- 4) Lab: Physical/Chemical Changes
- 5) Lab: Density
- 6) Lab: Measurement / Using basic lab equipment
- 7) Video: Lab Safety
- 8) Video: Scientific Method
- 9) Demo: Physical/Chemical Changes
- 10) Demo: Heterogeneous vs. Homogeneous Substances
- 11) Demo: Exothermic vs. endothermic
- 12) Demo: Lab Safety

## The Periodic Table

### A. Introduction

Students learn to use the periodic table to predict properties of elements. Students investigate the parts of the atom and the electron configuration of the atom. Students understand the importance of the periodic table. The history of chemistry is continued, emphasizing the discovery of atomic structure.

### B. Student Outcomes/Objectives

The students will be able to:

- 1) Cite examples of how technologies have been influenced by changes in our understanding of atomic theory from the early theories to modern models. (5.2) 12-B-1
- 2) Design a project that identifies a problem, purposes and implements a solution, and evaluates the consequences of that solution. (5.1) 12-A-1 WRS 3
- 3) Discuss in detail the development of atomic theory. (5.2) 12-B-3
- 4) Describe atomic structure including energy levels, sub-levels, orbitals, electron configurations and oxidation numbers. (5.6) 12-A-8
- 5) Use the periodic table to describe trends within groups and periods and predict properties of substances. (5.6) 12-A-5
- 6) Explain the relationship between atomic structure and the chemical behavior of elements. (5.6) 12-A-3
- 7) Explain the relationship between the number of protons and an element's identity. (5.6) 12-A-2
- 8) Explain the participation of neutrons in atomic weight and isotope identity. (5.6) 12-A-1
- 9) Recognize the significance of the organization of the periodic table on chemical and physical properties. (5.6) 12-A-5
- 10) Identify significant groups of the periodic table as elements related with common properties. (5.6) 12-A-5
- 11) Describe the periodic law. (5.6) 12-A-5
- 12) Describe a specific element's chemical and physical properties given a periodic table of elements. (5.6) 12-A-5
- 13) Explain how the forces that hold the nucleus of an atom together are stronger than the electrostatic forces present. (5.6) 12-A-6

### C. Learning Activities

- 1) Research Project: Use the internet to make atomic theory timeline
- 2) Research project: Use internet to research information on the periodic table

- 3) Lab: Flame Test
- 4) Lab: Spectroscopy
- 5) Video: Elements and the Periodic Table
- 6) Demo: Electron Cloud

## Elements, Compounds and Reactions

### A. Introduction

Students take their knowledge of the elements and learn how compounds are formed. Students write the two types of bonding, ionic and covalent. Students name compounds using standard chemical naming rules. Various examples of chemical reactions are investigated and classified. Students write chemical reactions and predict products.

### B. Student Outcomes/Objectives

The students will be able to:

- 1) Use models for a compound; write basic formulas and properly name salts, acids and bases. (5.6) 12-A-4 WRS 3
- 2) Describe the mechanisms of intra- and intermolecular bonding. (5.6) 12-A-6
- 3) Identify the five basic types of chemical reactions (synthesis, decomposition, single replacement, double replacement and neutralization). (5.6) 8-B-1
- 4) Describe, write and balance chemical equations. (5.6) 8-B-4 WRS 3
- 5) Explain the changes of properties between reactants and products in chemical reactions. (5.6) 8- B-1
- 6) Explain how matter undergoes chemical reactions whose nature, occurrence and rates are dependent upon the intrinsic features of atoms and molecules and upon the surrounding environments. (5.6) 12-B-1 (5.6) 12-A-6
- 7) Identify and predict a condition which will affect reaction rate given a description of the behavior of a reaction. (5.6) 12-B-1 (5.6) 12-B-2 WRS 3
- 8) Cite and explain the factors which affect rate of reaction, for example, concentration, pressure, temperature and catalysts. (5.6) 12-B-1
- 9) Explain how atoms can transfer or share electrons to form bonds in compounds. (5.6) 12-A-4
- 10) Identify the polarity of a bond by the uneven sharing of electrons. (5.6) 12-A-4
- 11) Explain that bonds form to gain stability. (5.6) 12-A-6
- 12) Use chemical symbols to represent atoms, compounds and chemical reactions. (5.6) 12-A-4
- 13) Explain the electrostatic forces present that hold an ionic compound together. (5.6) 12-A-4
- 14) Identify an organic compound, and draw the Lewis Structure of simple organic compounds. (5.6) 12-A-7 WRS 3
- 15) Draw Lewis Structures of covalent compounds and predict the shape and polarity of the molecule. (5.6) 12-A-4 WRS 3

### C. Learning Activities

- 1) Lab: Building Molecular Models using model kits
- 2) Lab: Making ionic compounds
- 3) Lab: Observing Chemical Equations
- 4) Lab: Investigating various covalent/ionic compounds
- 5) Lab: Activity of Metals
- 6) Lab: Solubility Rules
- 7) Practice Writing Ionic/Covalent bonds, chemical equations
- 8) Video: Chemical Bonding
- 9) Demo: Metals in acids

## The Mathematics of Chemistry

### A. Introduction

The calculation of mathematics related to chemistry is an important concept. Percent composition and empirical formula is introduced to students. Students learn the concept of the mole and Avogadro's number. Stoichiometric calculations increase the reasoning and logic skills of students. The gas laws investigate the mathematics behind compounds in the gaseous state.

### B. Student Outcomes/Objectives

The students will be able to:

- 1) Formulate mathematical relationships from data. (5.3) 12-C-1 WRS 3
- 2) Use appropriate mathematical tools to collect, display, model and analyze data. (5.3) 12-C-1 WRS 2
- 3) Explain the physical relationships expressed by mathematical equations. (5.3) 12-C-1 WRS 3
- 4) Use computer spreadsheets, graphing and database programs to assist in quantitative analysis. (5.3) 12-D-1 WRS 2
- 5) List examples of scientist responsible for the development of major ideas and theories, for example, Boyles' Law. (5.2) 12-B-1
- 6) Explain the interactive relationships between science, technology and society both historically and in a contemporary setting. (5.2) 12-A-1
- 7) Calculate quantitative relationships of matter and explain the behavior using the mole concept. (5.3) 8-B-1
- 8) Use kinetic theory to explain the theoretical basis for gas laws and use the various gas laws to solve problems. (5.6) 8-A-2 (5.3) 12-D-1
- 9) Calculate the percent composition of a substance. (5.3) 12-C-1
- 10) Calculate the empirical formula of a substance. (5.3) 12-C-1
- 11) Calculate the number of atoms or molecules of a substance by using Avogadro's number. (5.3) 12-A-1
- 12) Calculate the moles of a substance from grams of a substance, and vice versa. (5.3) 12-C-1 (5.6) 12-A-7
- 13) Use dimensional analysis to solve stoichiometry problems. (5.3) 12-C-1 WRS 3
- 14) Calculate grams and moles of a substance using a complete balanced equation and stoichiometry. (5.3) 12-C-1 (5.6) 12-A-7 WRS 3
- 15) Discuss the role of gases in our environment. (5.10) 12-B-2

### C. Learning Activities

- 1) Use calculator to solve mathematical problems
- 2) Lab: Percent Composition

3) Lab: Empirical Formula

4) Lab: Limiting Reactants

5) Lab: Charles' Law

6) Hot Air Balloon Activity

7) Video: Global Warming

8) Video: Gas Laws

## Experimentation Chemistry

### A Introduction

Students learn important concepts of solution chemistry and acid – base chemistry. The real world applications of acids and bases are discussed. Qualitative analysis is performed as a final application of chemistry. Qualitative analysis allows students to achieve independence in the laboratory and to realize how chemists work.

### B. Student Outcomes/Objectives

The students will be able to:

- 1) Denote the conditions that establish an equilibrium system and recognize the existence of equilibrium systems in the real world. (5.6) 12-A-7
- 2) Recognize and describe the importance of negative results. (5.1) 12-B-2 WRS 3
- 3) Explain why a control is essential to experimental design. (5.1) 12-A-1 WRS 3
- 4) Apply and recognize the relationship between a control and a variable in experimental investigation. (5.1) 12-A-1 WRS 3
- 5) Select and use appropriate instrumentation to design and conduct investigations. (5.1) 12-B-1 WRS 2
- 6) Use technology to communicate the design and results of an investigation.(5.4) 12-C-1 WRS 2
- 7) Evaluate conclusions and weigh evidence. (5.1) 12-A-1 WRS 3
- 8) Explain how results of experimentation lead to further investigation. (5.1) 12-B-2 WRS 3
- 9) Perform laboratory work which is focused on qualitative analysis and identification of an unknown compound. (5.4) 12-C-1 WRS 4, 5
- 10) Recognize the difference between acids and bases and how to measure and identify them through experimentation. (5.6) 12-A-4 WRS 4, 5
- 11) Learn terms related to solution chemistry. (5.6) 12-A-6
- 12) Calculate molarity and other mathematical equations relating to solution chemistry. (5.3) 12-B-1
- 13) Recognize how acids and bases affect people in their daily lives. (5.6) 12-A-6
- 14) Determine how temperature, pressure and concentration can affect solubility. (5.6) 12-B-1
- 15) Gain experience of working as a chemist. (5.1) 12-A-1 WRS 1

### C. Learning Activities

- 1) Lab: Titration
- 2) Lab: Acid/Base Recognition
- 3) Demo: Acid/Bases

- 4) Video: Acid Rain
- 5) Video: Acids/Bases
- 6) Demo: Factors involving solubility
- 7) Research project: Qualitative analysis related lab terms on the internet
- 8) Lab Project: Qualitative analysis (find known and/or unknown ions)

## **Assessment**

Student proficiency (satisfactory achievement) in each of the outcomes/objectives listed in this guide shall be determined by student attainment of the 70% district passing standard which pertains to all curricula and populations. Such proficiency shall be measured by a multiplicity of evaluation techniques and instruments, which includes, but is not restricted to the following:

- 1) Teacher-made tests/quizzes
- 2) Class participation
- 3) Homework assignments
- 4) Research papers/reports
- 5) Projects
- 6) Writing assignments
- 7) Oral reports and presentations
- 8) Notebooks/journals
- 9) Portfolios
- 10) Cooperative group projects/activities
- 11) Laboratory work

## **Instructional Resources**

Daub, G. William and William S. Seese, Basic Chemistry, Prentice Hall, 1996.