Grades 9-12 Science  
Chemistry

Gas Laws and The Particle Nature of Matter

Stage 1: Desired Results

Catholic Standards

DOC All Grades DOC: Catholic Standards

The Profession of Faith

Students will be able to

1. Recognize God in the world's order, beauty, and goodness (CCC 32).

Life in Christ

Students will be able to

2. Know that we must assume responsibility for the acts we perform (CCC 1781).

12. Respect the integrity of all creation, including animals, plants, and all nature (CCC 2415).

Targeted Standards

NGSS Grade 9-12 NGSS: Science and Engineering Practices

Practice 8. Obtaining, evaluating, and communicating information

Obtaining, evaluating, and communicating information in 912 builds on K8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order 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 usefulness of each source.

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Practice 6. Constructing explanations (for science) and designing solutions (for engineering)

Constructing explanations and designing solutions in 912 builds on K8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.

Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Practice 7. Engaging in argument from evidence

Engaging in argument from evidence in 912 builds on K8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.

Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Practice 1. Asking questions (for science) and defining problems (for engineering)

Asking questions and defining problems in 912 builds on K8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.

Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.

Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.

Ask questions to clarify and refine a model, an explanation, or an engineering problem.

Evaluate a question to determine if it is testable and relevant.

Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.

Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.

Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and/or environmental considerations.

Practice 2. Developing and using models

Modeling in 912 builds on K8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria.

Design a test of a model to ascertain its reliability.

Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.

Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Practice 3. Planning and carrying out investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigations design to ensure variables are controlled.

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.

Select appropriate tools to collect, record, analyze, and evaluate data.

Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.

Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

Practice 4. Analyzing and interpreting data

Analyzing data in 912 builds on K8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.

Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.

Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.

Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.

Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Practice 5. Using mathematics and computational thinking

Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Apply techniques of algebra and functions to represent and solve scientific and engineering problems.

Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model makes sense by comparing the outcomes with what is known about the real world.

Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).

OH Grade 9-12 OH: Science (2011)

HS Chemistry

Science Inquiry and Application During the years of grades 9 through 12 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

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 defend a scientific argument.

Course Content: Structure and Properties of Matter

Quantifying matter

Course Content: Interactions of Matter

Gas laws: Pressure, volume and temperature

Gas laws: Ideal gas law

OH Grades 11-12 OH: Literacy in History/Social Studies, Science, & Technical Subjects 6-12

Writing

Text Types and Purposes 1. Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence.

WHST.11-12.1. Write arguments focused on discipline-specific content.

WHST.11-12.1a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.

WHST.11-12.1b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audiences knowledge level, concerns, values, and possible biases.

WHST.11-12.1c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.

WHST.11-12.1d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

WHST.11-12.1e. Provide a concluding statement or section that follows from or supports the argument presented.

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

WHST.11-12.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

WHST.11-12.2a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.

WHST.11-12.2b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audiences knowledge of the topic.

WHST.11-12.2c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.

WHST.11-12.2d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.

WHST.11-12.2e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).

Production and Distribution of Writing 4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

WHST.11-12.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.

WHST.11-12.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

WHST.11-12.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

Research to Build and Present Knowledge 7. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

WHST.11-12.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.

WHST.11-12.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

Draw evidence from literary or informational texts to support analysis, reflection, and research.

WHST.11-12.9. Draw evidence from informational texts to support analysis, reflection, and research.

Range of Writing 10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

WHST.11-12.10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Reading: Science & Technical Subjects

Key Ideas and Details 1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

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.

Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.

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.

Analyze how and why individuals, events, or ideas develop and interact over the course of a text.

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 4. Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

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 1112 texts and topics.

Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole.

RST.11-12.5. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.

Assess how point of view or purpose shapes the content and style of a text.

RST.11-12.6. Analyze the authors 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 7. Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.

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.

Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.

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.

Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

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.

Read and comprehend complex literary and informational texts independently and proficiently.

RST.11-12.10. By the end of grade 12, read and comprehend science/technical texts in the grades 1112 text complexity band independently and proficiently.

Capacities of the Literate Individual

Students Who are College and Career Ready in Reading, Writing, Speaking, Listening, & Language

They demonstrate independence.

Catholic Identity

DOC All Grades Catholic Identity

Catholic Social Justice Teachings

Life and Dignity of the Human Person

Rights and Responsibilities

The Dignity of Work and the Rights of Workers

Call to Family, Community, and Participation

Option for the Poor and Vulnerable

Solidarity

Care for God's Creation

The Rights of Children

1. THE RIGHT TO A CATHOLIC COMMUNITY that witnesses to Christ and the Gospel by protecting them from child abuse, including sexual abuse and neglect.

2. THE RIGHT TO A SAFE ENVIRONMENT that promotes care, protection, and security.

3. THE RIGHT TO BE RESPECTED AS INDIVIDUALS with human dignity.

4. THE RIGHT TO WORK ACTIVELY TOWARD THEIR OWN EMPOWERMENT through the development of their gifts and talents.

5. THE RIGHT TO A LEARNING ENVIRONMENT THAT VALUES COOPERATION and challenges its members to critical and reflective thinking in their search for truth.

6. THE RIGHT TO DEVELOP POSITIVE, RESPONSIBLE AND CARING ATTITUDES AND BEHAVIORS TOWARD OTHERS and to recognize the rights of others to be safe and free from harassment and abuse.

7. THE RIGHT TO LEARN THE SKILL OF SELF PROTECTION by identifying safe and unsafe situations.

8. THE RIGHT TO LEARN RESPONSIBILITY for themselves and their actions.

9. THE RIGHT TO MAKE RESPONSIBLE DECISIONS founded on religious conviction.

10. THE RIGHT TO GUIDANCE FROM THE CHURCH in their development as loving people.

Summary

In this unit students will discover the particle nature of matter through working with the Gas Laws. Kinetic molecular theory of gases will be the lens through which students begin to think about the submicroscopic structure of matter as individual particles which move and interact. Investigating the gas laws provides students the opportunity to design experiments, gather data, and analyze that data mathematically and graphically to develop models. This is an opportunity to review experimental design, lab safety, and the nature of science. This is one of many possible introductory units in a chemistry course. The course standards may be assessed in any order.

Unit Goals

1. Students will understand the components of experimental design.
2. Students will understand how mathematical models are developed and used in physical systems.
3. Students will understand that all matter is composed of small particles which are constantly moving and interacting.
4. Students will understand the relationships between gas properties in gas laws.

Big Ideas

1. Matter is made of particles.
2. Models are used to represent physical systems.

Enduring Understandings

1. Scientific investigations involve observations, hypotheses, and experiments.
2. The kinetic molecular theory of matter explains the properties of matter.
3. Temperature is a measure of kinetic energy of particles.
4. Pressure is a product of collisions of particles with the container.
5. Temperature, pressure, and volume are mathematically related:

* As temperature increases, pressure increases.
* As temperature increases, volume increases.
* As volume increases, pressure decreases.

Content

**Quantifying Matter**

1. accuracy
2. precision
3. scientific protocols for quantifying the properties of matter accurately and precisely
4. metric measurement systems
5. significant digits or figures
6. scientific notation
7. error analysis
8. dimensional analysis
9. procedures for measurements in macroscopic and submicroscopic domains
10. the mole is used to translate between the atomic and macroscopic levels
11. a mole is a counting number, like a dozen

**Gas Laws**

**Pressure, Volume, and Temperature**

1. Pressure, temperature, and volume are important macroscopic properties of gases.
2. The kinetic molecular theory can be used to explain the macroscopic properties of gases through the motion and interactions of its particles.
3. The relationship between two properties of gases can be quantified, described and explained using the kinetic molecular theory when all other properties are held constant.
4. Kinetic molecular theory explains real-world phenomena (see examples in essential questions).
5. Problems involving changes in temperature, pressure, and volume can be solved mathematically.
6. The Kelvin temperature scale must be used because only this scale is directly proportional to the average kinetic energy of particles.
7. The Kelvin temperature scale has its minimum temperature at absolute zero.
8. At absolute zero, all motion theoretically stops.

**Ideal Gas Law**

1. Equal volumes of gases at the same temperature and pressure contain equal number of particles (Avogadro's Law).
2. If the temperature is constant, as the pressure of a gas increases, the volume decreases (Boyle's Law).
3. If the pressure is constant, as the temperature of an enclosed gas increases, the volume increases (Charles' Law).
4. If the volume is constant, as the temperature of an enclosed gas increases, the pressure increases (Gay-Lussac's Law).
5. When only the amount of gas is constant, the combined gas law describes the relationship among pressure, volume, and temperature.
6. The ideal gas law (PV=nRT where R is the ideal gas constant) can be used to solve problems for an unchanging gaseous system.
7. Real gases differ most from ideal gases at low temperatures and high pressures.

Adapted from Ohio Revised Science Standards and Model Curriculum

Resources

* <http://education.ohio.gov/getattachment/Topics/Ohio-s-New-Learning-Standards/Science/HSscience_Model_Curriculum_April2014-1.pdf.aspx>

Skills

**Bloom's Taxonomy/DOK**

**Remember (Level 1)**

1. Identify properties that determine gas behavior.
2. Measure the volume, temperature, and pressure of a gas.
3. Identify the general approach to solving a problem.
4. Write numbers in scientific notations.

**Understand (Level 1 and 2)**

1. Explain why gases are easier to compress than solids or liquids.
2. Describe factors that affect gas pressure.
3. Describe the relationship among the pressure, volume, and temperature of a gas.
4. Describe the steps for solving numeric and nonnumeric problems.

**Analyze (Level 3)**

1. Graph lab data.
2. Quantify, describe, and explain the relationship between two properties of gases when other properties are held constant.
3. Explain real world phenomena using kinetic molecular theory.
4. Solve problems involving changes in temperature, pressure, and volume.
5. Use the Kelvin temperature scale to solve problems.
6. Use the ideal gas law to solve problems for an unchanging gaseous system.
7. Explain why measurements must be reported to the correct number of significant figures.
8. Use dimensional analysis to solve problems.

**Evaluate (Level 3 and Level 4)**

1. Perform scientific investigations.
2. Determine the conditions when real gases are most likely to differ from ideal gases.
3. Evaluate accuracy and precision.

**Create (Level 4)**

1. Design scientific investigations.
2. Explore the relationships between the volume, temperature and pressure in the laboratory or through computer simulations or virtual experiments.

Essential Questions

1. How can mathematical models be used to represent physical systems?
2. When designing an experiment, how can you ensure that your results are meaningful and valid?
3. How do gases respond to changes in pressure, volume, and temperature?
4. How can everyday observations be explained by Kinetic Molecular Theory?
5. To what extent do real gases differ from ideal gases?
6. Why is the ideal gas law useful even though ideal gases do not exist?
7. Why does pressure increase when temperature increases?
8. Why does a basketball go flat on a cold day?
9. Why does volume increase when temperature increases?
10. Why does tire pressure increase in hot weather?
11. Why do hot air balloons rise?

Stage 2: Assessment Evidence

Experimental Design with The Fortune Fish

Formative: Lab Assignment

Quick project to review the key aspects of experimental design. Allow students to ask questions and develop their own procedures for gathering data to answer their questions.

Exploration of Gases

Formative: Lab Assignment

Students observe gas behavior and explain observations using kinetic molecular theory.

Exploration of Kinetic Molecular Theory and Gas Laws

Formative: Lab Assignment

Students use online simulator to visualize gas particles and make connections between kinetic molecular theory and gas laws.

Boyle's Law Lab

Summative: Lab Assignment

Students develop the equation for Boyle's law from lab data. Students measure volume as pressure is changed.

Charles' Law Lab

Summative: Lab Assignment

Students develop the equation for Charles' law from lab data. Students measure volume as temperature is changed.

POGIL Activities

Formative: Cooperative Group Work

Fundamentals of Experimental DesignOrganizing DataSignificant Digits and MeasurementSignificant ZerosKinetic Molecular TheoryGas Variables

Laboratory Work

Formative: Lab Assignment

Teachers can assign labs from the laboratory manual, create their own labs, or use web sources, many of which are listed in the reference section. Laboratory exercises are a necessary part of high school science; however, not all schools have the same equipment, so any variety of labs may be used to aid students in their understanding of unit concepts. They can be formative, exploring a new concept, or summative, showing a practical application of concept knowledge.

Lab Report

Summative: Writing Assignment

Following a laboratory investigation, the student analyzes the data collected, applies concepts to real life situations, and synthesizes information from the lab, class discussions, and additional research into a formal lab report. RERUN Recall what you did in lab. Explain how your hypothesis was supported or not supported by your data. Results: Organize data in a logical and appropriate manner such as chart, graph, etc. Unexpected results: Explain all errors and/or unexpected results. New things learned must be articulated clearly and completely.

Graphic Organizer

Formative: Graphic Organizer

Students make connections between concepts.

Homework Problems

Formative: Homework

Students solve problems involving quantifying matter and gas laws.

Quizzes

Formative: Quiz

Quizzes are used to gauge the progress of student understanding of learning content and skills.

White Board Races

Formative: Cooperative Group Work

Students work in pairs to answer questions presented to the class. Student pairs must show all work on individual white boards which they hold up for immediate feedback. More whiteboarding strategies are described in the link.

Unit Test

Summative: Test

Unit Test

Resources

Stage 3: Learning Plan

Learning Experiences

1. Guided Inquiry
2. Cooperative Learning Groups
3. POGIL Activities
4. Graphic Organizers
5. Small Group and Class Discussions
6. Direct Instruction
7. Critical Thinking

Resources

* <https://pogil.org/about>

Technology Integration

1. Smart Board
2. Smart phone
3. Chromebooks, computers Internet
4. Graphing software (Excel, LoggerPro)
5. Vernier software and hardware
6. Pasco software and hardware
7. iPad apps
8. Phet simulations
9. LCD projector
10. PowerPoint
11. Internet resources
12. Online video clips

Resources

**Books**

1. Trout, L. (2012). *POGIL activities for high school chemistry*. Batavia, IL: Flinn Scientific, Inc.
2. Wilbraham, A., et al. (2012). *Chemistry.* New York: Pearson.
3. Timberlake, K., and Timberlake, W. (2008). *Basic chemistry*, 2nd edition. New York: Prentice Hall.
4. Buthelezi,T., Dingrando, L., Hainen, N. (2008). *Chemistry: Matter and change. New York:* Glencoe, 2008.
5. Volz, D.L., and Smola, R. (2009). *Investigating chemistry through inquiry*. Beaverton, OR: Vernier.
6. Holmquist, D.D., Randall, J., and Volz, D.L. (2007). *Chemistry with Vernier.* Beaverton, OR: Vernier.

Resources

* <http://pubs.acs.org/journal/jceda8>

Grades 9-12 Science  
Chemistry

Atomic Structure and The Periodic Table

Stage 1: Desired Results

Catholic Standards

DOC All Grades DOC: Catholic Standards

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Students will be able to

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NGSS Grade 9-12 NGSS: Science and Engineering Practices

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Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

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Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.

Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Practice 1. Asking questions (for science) and defining problems (for engineering)

Asking questions and defining problems in 912 builds on K8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.

Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.

Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.

Ask questions to clarify and refine a model, an explanation, or an engineering problem.

Evaluate a question to determine if it is testable and relevant.

Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.

Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.

Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and/or environmental considerations.

Practice 2. Developing and using models

Modeling in 912 builds on K8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria.

Design a test of a model to ascertain its reliability.

Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.

Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Practice 3. Planning and carrying out investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigations design to ensure variables are controlled.

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.

Select appropriate tools to collect, record, analyze, and evaluate data.

Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.

Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

Practice 4. Analyzing and interpreting data

Analyzing data in 912 builds on K8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.

Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.

Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.

Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.

Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Practice 5. Using mathematics and computational thinking

Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Apply techniques of algebra and functions to represent and solve scientific and engineering problems.

Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model makes sense by comparing the outcomes with what is known about the real world.

Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).

OH Grade 9-12 OH: Science (2011)

HS Chemistry

Science Inquiry and Application During the years of grades 9 through 12 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

Identify questions and concepts that guide 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 defend a scientific argument.

Course Content: Structure and Properties of Matter

Atomic structure: Evolution of atomic models/theory

Atomic structure: Electrons

Atomic structure: Electron configurations

Periodic table: Properties

Periodic table: Trends

Quantifying matter

OH Grades 11-12 OH: Literacy in History/Social Studies, Science, & Technical Subjects 6-12

Writing

Text Types and Purposes 1. Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence.

WHST.11-12.1. Write arguments focused on discipline-specific content.

WHST.11-12.1a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.

WHST.11-12.1b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audiences knowledge level, concerns, values, and possible biases.

WHST.11-12.1c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.

WHST.11-12.1d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

WHST.11-12.1e. Provide a concluding statement or section that follows from or supports the argument presented.

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

WHST.11-12.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

WHST.11-12.2a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.

WHST.11-12.2b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audiences knowledge of the topic.

WHST.11-12.2c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.

WHST.11-12.2d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.

WHST.11-12.2e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).

Production and Distribution of Writing 4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

WHST.11-12.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.

WHST.11-12.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

WHST.11-12.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

Research to Build and Present Knowledge 7. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

WHST.11-12.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.

WHST.11-12.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

Draw evidence from literary or informational texts to support analysis, reflection, and research.

WHST.11-12.9. Draw evidence from informational texts to support analysis, reflection, and research.

Range of Writing 10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

WHST.11-12.10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Reading: Science & Technical Subjects

Key Ideas and Details 1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

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.

Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.

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.

Analyze how and why individuals, events, or ideas develop and interact over the course of a text.

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 4. Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

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 1112 texts and topics.

Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole.

RST.11-12.5. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.

Assess how point of view or purpose shapes the content and style of a text.

RST.11-12.6. Analyze the authors 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 7. Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.

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.

Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.

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.

Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

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.

Read and comprehend complex literary and informational texts independently and proficiently.

RST.11-12.10. By the end of grade 12, read and comprehend science/technical texts in the grades 1112 text complexity band independently and proficiently.

Capacities of the Literate Individual

Students Who are College and Career Ready in Reading, Writing, Speaking, Listening, & Language

They demonstrate independence.

Catholic Identity

DOC All Grades Catholic Identity

Catholic Social Justice Teachings

Life and Dignity of the Human Person

Rights and Responsibilities

The Dignity of Work and the Rights of Workers

Call to Family, Community, and Participation

Option for the Poor and Vulnerable

Solidarity

Care for God's Creation

The Rights of Children

1. THE RIGHT TO A CATHOLIC COMMUNITY that witnesses to Christ and the Gospel by protecting them from child abuse, including sexual abuse and neglect.

2. THE RIGHT TO A SAFE ENVIRONMENT that promotes care, protection, and security.

3. THE RIGHT TO BE RESPECTED AS INDIVIDUALS with human dignity.

4. THE RIGHT TO WORK ACTIVELY TOWARD THEIR OWN EMPOWERMENT through the development of their gifts and talents.

5. THE RIGHT TO A LEARNING ENVIRONMENT THAT VALUES COOPERATION and challenges its members to critical and reflective thinking in their search for truth.

6. THE RIGHT TO DEVELOP POSITIVE, RESPONSIBLE AND CARING ATTITUDES AND BEHAVIORS TOWARD OTHERS and to recognize the rights of others to be safe and free from harassment and abuse.

7. THE RIGHT TO LEARN THE SKILL OF SELF PROTECTION by identifying safe and unsafe situations.

8. THE RIGHT TO LEARN RESPONSIBILITY for themselves and their actions.

9. THE RIGHT TO MAKE RESPONSIBLE DECISIONS founded on religious conviction.

10. THE RIGHT TO GUIDANCE FROM THE CHURCH in their development as loving people.

Summary

In this unit students will analyze the structure and properties of matter. The history of atomic theories will be discussed, illustrating the process of science and how our understanding of the world changes with time and improving technology. It is important for students to come to realize that there is no such thing as the "right" model of the atom, but rather several models can be used depending on the detail needed for a particular theory or investigation. The study of atomic structure will culminate with electron configurations which determine periodic properties and the trends of the periodic table.

Unit Goals

1. Students will understand how atomic models and theories have changed through history.
2. Students will understand the role electrons play in the properties and interactions of atoms.
3. Students will understand how electrons are arranged in the atom.
4. Students will understand that energy can be quantized.
5. Students will understand how the trends and properties of elements on the periodic table are caused by the arrangement of electrons in the atom.
6. Students will understand how to quantify matter.

Big Ideas

1. Atomic structure dictates the properties and interactions of matter.
2. Matter can be quantified in several ways.

Enduring Understandings

1. The theories and models describing the atom continue to evolve.
2. Electrons are arranged in predictable patterns around the atom.
3. Valence electrons determine the properties of elements.
4. Valence electrons determine how atoms interact.
5. The arrangement of elements on the periodic table illustrates the trends caused by the arrangement of electrons in the atom.
6. The periodic table is the greatest chemistry study guide ever created.

Content

**Atomic Structure**

**Evolution of Atomic Models/Theory**

1. The atomic theory has developed over time.
2. Atomic models are constructed to explain experimental evidence and make predictions.
3. Changes in atomic models over time exemplify how scientific knowledge changes as new evidence emerges and how technological advancements like electricity extend the boundaries of scientific knowledge.
4. Thompson's study of electrical discharges in cathode-ray tubes led to the discovery of the electron and the development of the plum pudding model of the atom.
5. Rutherford's experiment, in which he bombarded gold foil with alpha particles, led to the discovery that most of the atom consists of empty space with a relatively small, positively charged nucleus.
6. Bohr used data from atomic spectra to propose a planetary model of the atom in which electrons orbit the nucleus, like planets around the sun.
7. Schrdinger used the idea that electrons travel in waves to develop a model in which electrons travel randomly in regions of space called orbitals (quantum mechanical model).
8. All historical models of atoms can be helpful in different circumstances.
9. Many physical properties of substances can be explained by the indivisible sphere model of the atom.
10. Bohr's planetary model is useful to explain and predict periodic trends in the properties of elements.

**Electrons**

1. There is a region of space surrounding the nucleus in which there is a high probability of finding an electron (electron cloud or orbital).
2. Data from atomic spectra (emission and absorption) give evidence that electrons can only exist at certain discrete energy levels and not at energies between these levels.
3. Atoms are usually in the ground state where the electrons occupy orbitals with the lowest available energy.
4. The atom can become excited when the electrons absorb a photon with the precise amount of energy to move to an orbital with higher energy.
5. An electron emits a photon when it drops back down to the lower energy level, and the energy of the photon is equal to the energy difference between the levels.
6. The energy of a photon is indicated by the frequency of the light and can be measured.

**Electron Configurations**

1. Each element has a unique emission and absorption spectrum due to its unique electron configuration and specific electron energy jumps possible.
2. Electron energy levels consist of sublevels (s, p, d, and f) each with a characteristic number and shape of orbitals.
3. Orbital diagrams and electron configurations can be constructed to show the location of the electrons in an atom using established rules.
4. Valence electrons are responsible for most of the chemical properties of the elements.

**Periodic Table: Properties, Trends**

1. Similarities in the configuration of the valence electrons for a particular group of the periodic table result in similar chemical and physical properties of the elements in the group.
2. The electron configuration of an atom can be written from the position on the periodic table.
3. Repeating patterns in the electron configurations for elements on the periodic table explain many of the trends in the properties observed.
4. Atomic theory and electron configurations must be used to explain trends in properties across periods or down columns including:

atomic radii

ionic radii

first ionization energies

electronegativities

**Quantifying Matter**

1. Mass can reflect the number of particles present.
2. Elemental samples are a mixture of several isotopes with different masses.
3. The atomic mass of an element is calculated given the mass and relative abundance of each isotope of the element as it exists in nature.
4. The mole is used to translate between the atomic and macroscopic levels.
5. A mole is a counting number, like a dozen.
6. A mole is equal to the number of particles in exactly 12 grams of carbon-12 atoms.
7. The mass of one mole of a substance is equal to its formula mass in grams.
8. The formula mass for a substance can be used in conjunction with Avogadro's number and the density of a substance to convert between mass, moles, volume, and number of particles of a sample.

Adapted from Ohio Revised Science Standards and Model Curriculum

Resources

* <http://education.ohio.gov/getattachment/Topics/Ohio-s-New-Learning-Standards/Science/HSscience_Model_Curriculum_April2014-1.pdf.aspx>

Skills

**Bloom's Taxonomy/DOK**

**Remember (Level 1)**

1. Describe how the modern periodic table is organized.
2. Identify elements by atomic spectra.
3. Observe similarities in the valence configuration of elements in the same group of the periodic table.
4. List the three rules for writing the electron configurations of elements.

**Understand (Level 1 and 2)**

1. Explain how isotopes of an element differ.
2. Calculate atomic mass of an element.
3. Use the mole to translate between atomic and macroscopic levels.
4. Use formula mass, Avogadro's number, and density to convert between mass, moles, volume, and number of particles.
5. Explain experimental evidence for atomic models.
6. Explain physical properties of substances using different models of the atom.
7. Classify elements based on electron configuration.

**Analyze (Level 3)**

1. Perform dimensional analysis.
2. Analyze atomic spectra (emission and absorption).
3. Draw ground state electron configurations.
4. Analyze ground state electron configurations.
5. Analyze excited state electron configurations.
6. Draw s and p sub levels.
7. Use established rules to create orbital diagrams and electron configurations (extended and noble gas notation) for any element in the first three periods.
8. Write electron configurations from the position on the periodic table.
9. Explain how the frequencies of light are related to changes in electron energies.
10. Explain and predict periodic trends in the properties of elements using Bohr's planetary model.
11. Explain trends in properties of elements on the periodic table using repeating patterns in electron configuration.
12. Explain trends in properties across periods or down columns.

**Evaluate (Level 3 and Level 4)**

1. Predict properties of atoms based on atomic models.
2. Determine the energy emitted by certain transition between atomic orbitals.
3. Explain patterns for atomic size, first ionization energy, ionic size, and electronegativity according to electron configurations and atomic structure.

**Create (Level 4)**

1. Construct atomic models.
2. Critique historical models of the atom relating a model to the technology and observations of the time.

Essential Questions

1. How has the understanding of atomic structure changed over history and what caused these changes?
2. How are atoms of one element different from atoms of another element?
3. Why do electrons influence chemical and physical properties?
4. Why is understanding the arrangements of electrons in atoms essential to predicting properties of elements?
5. What exceptions are there to the predicted electron configurations and why do these exceptions exist?
6. What happens when electrons in atoms absorb or release energy?
7. How is the arrangement of the elements on the periodic table related to electron configuration, atomic mass, atomic radius, atomic number, electronegativity, ionization energy, etc.?
8. How can atoms be counted?

Stage 2: Assessment Evidence

Atomic History Webquest

Formative: Online Learning

Students use Internet and textbook resources to answer the questions in this webquest. Students explore the scientists and models that have influenced the development of atomic theory.

Density Lab

Formative: Lab Assignment

Students develop their own procedure to measure the density of an irregularly shaped unknown metal substance. Students then use their results to identify the substance.

Atomic Spectra Lab

Formative: Lab Assignment

Students observe the light emitted from samples of different elements through diffraction gratings. Students should document the colors of light seen and approximate wavelength. Students should identify unknown elements by comparing observed atomic emission spectra with known atomic emission spectra.

Flame Test Lab

Formative: Lab Assignment

Students observe the color of light emitted when solutions of metal cations are passed through the flame of a Bunsen burner. Students can identify unknowns by comparing the colors observed to known substances.

Periodic Trends of the Periodic Table

Formative: Lab Assignment

Lab in which students build 3D models and bar graphs of the different properties across the periodic table and discover the trends.

Bean Lab Developing the Mole Concept

Formative: Lab Assignment

Students precisely measure the masses of various types of dried beans and calculate the relative mass for each type of bean. This is then connected to the way in which atoms are measured and connections are made to the concept of the mole.

POGIL Activities

Formative: Cooperative Group Work

IsotopesIonsAverage Atomic MassCoulombic AttractionElectron Energy and LightElectron ConfigurationsCracking the Periodic Table CodePeriodic TrendsRelative Mass and the Mole

White Board Races

Formative: Cooperative Group Work

Students work in pairs to answer questions presented to the class. Student pairs must show all work on individual white boards which they hold up for immediate feedback. More whiteboarding strategies are described in the link.

Homework Problems

Formative: Homework

Students solve problems involving atomic structure and the periodic table.

Graphic Organizer

Formative: Graphic Organizer

Students make connections between concepts.

Laboratory Work

Formative: Lab Assignment

Teachers can assign labs from the laboratory manual, create their own labs, or from web sources, many of which are listed in the reference section. Laboratory exercises are a necessary part of high school science, however not all schools have the same equipment so any variety of labs may be used to aid students in their understanding of unit concepts. They can be formative, exploring a new concept, or summative, showing a practical application of concept knowledge.

Lab Report

Summative: Writing Assignment

Following a laboratory investigation, the student analyzes the data collected, applies concepts to real life situations, and synthesizes information from the lab, class discussions, and additional research into a formal lab report. RERUN Recall what you did in lab. Explain how your hypothesis was supported or not supported by your data. Results: Organize data in a logical and appropriate manner such as chart, graph, etc. Unexpected results: Explain all errors and/or unexpected results. New things learned must be articulated clearly and completely.

Quizzes

Formative: Quiz

Quizzes are used to gauge the progress of student understanding of learning content and skills.

Unit Test

Summative: Test

Unit Test

Stage 3: Learning Plan

Learning Experiences

1. Guided Inquiry
2. Cooperative Learning Groups
3. POGIL Activities
4. Graphic Organizers
5. Small Group and Class Discussions
6. Direct Instruction
7. Critical Thinking

Resources

* <https://pogil.org/about>

Technology Integration

1. Smart Board
2. Smart phone
3. Chromebooks, Computers internet
4. Graphing software (Excel, LoggerPro)
5. Vernier software and hardware
6. Pasco software and hardware
7. iPad apps
8. Phet simulations
9. LCD projector
10. PowerPoint
11. Internet resources
12. Online video clips

Resources

**Books**

1. Trout, L. (2012). *POGIL activities for high school chemistry*. Batavia, IL: Flinn Scientific, Inc.
2. Wilbraham, A., et al. (2012). *Chemistry.* New York: Pearson.
3. Timberlake, K., and Timberlake, W. (2008). *Basic chemistry*, 2nd edition. New York: Prentice Hall.
4. Buthelezi,T., Dingrando, L., Hainen, N. (2008). *Chemistry: Matter and change. New York:* Glencoe, 2008.
5. Volz, D.L., and Smola, R. (2009). *Investigating chemistry through inquiry*. Beaverton, OR: Vernier.
6. Holmquist, D.D., Randall, J., and Volz, D.L. (2007). *Chemistry with Vernier.* Beaverton, OR: Vernier.

Resources

* <https://www.youtube.com/playlist?list=PL8dPuuaLjXtPHzzYuWy6fYEaX9mQQ8oGr>

Grades 9-12 Science  
Chemistry

Chemical Bonding and Representing Compounds

Stage 1: Desired Results

Catholic Standards

DOC All Grades DOC: Catholic Standards

The Profession of Faith

Students will be able to

1. Recognize God in the world's order, beauty, and goodness (CCC 32).

Life in Christ

Students will be able to

2. Know that we must assume responsibility for the acts we perform (CCC 1781).

12. Respect the integrity of all creation, including animals, plants, and all nature (CCC 2415).

Targeted Standards

NGSS Grade 9-12 NGSS: Science and Engineering Practices

Practice 8. Obtaining, evaluating, and communicating information

Obtaining, evaluating, and communicating information in 912 builds on K8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order 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 usefulness of each source.

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Practice 6. Constructing explanations (for science) and designing solutions (for engineering)

Constructing explanations and designing solutions in 912 builds on K8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.

Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Practice 7. Engaging in argument from evidence

Engaging in argument from evidence in 912 builds on K8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.

Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Practice 1. Asking questions (for science) and defining problems (for engineering)

Asking questions and defining problems in 912 builds on K8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.

Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.

Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.

Ask questions to clarify and refine a model, an explanation, or an engineering problem.

Evaluate a question to determine if it is testable and relevant.

Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.

Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.

Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and/or environmental considerations.

Practice 2. Developing and using models

Modeling in 912 builds on K8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria.

Design a test of a model to ascertain its reliability.

Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.

Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Practice 3. Planning and carrying out investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigations design to ensure variables are controlled.

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.

Select appropriate tools to collect, record, analyze, and evaluate data.

Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.

Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

Practice 4. Analyzing and interpreting data

Analyzing data in 912 builds on K8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.

Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.

Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.

Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.

Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Practice 5. Using mathematics and computational thinking

Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Apply techniques of algebra and functions to represent and solve scientific and engineering problems.

Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model makes sense by comparing the outcomes with what is known about the real world.

Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).

OH Grade 9-12 OH: Science (2011)

HS Chemistry

Science Inquiry and Application During the years of grades 9 through 12 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

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 defend a scientific argument.

Course Content: Structure and Properties of Matter

Intramolecular chemical bonding: Ionic

Intramolecular chemical bonding: Polar/covalent

Representing compounds: Formula writing

Representing compounds: Nomenclature

Representing compounds: Models and shapes (Lewis structures, ball and stick, molecular geometries)

Quantifying matter

Phases of matter

Intermolecular chemical bonding: Types and strengths

Intermolecular chemical bonding: Implications for properties of substances-Melting and boiling point

Intermolecular chemical bonding: Implications for properties of substances-Solubility

Intermolecular chemical bonding: Implications for properties of substances-Vapor pressure

Course Content: Interactions of Matter

Stoichiometry: Molar calculations

Stoichiometry: Solutions

OH Grades 11-12 OH: Literacy in History/Social Studies, Science, & Technical Subjects 6-12

Writing

Text Types and Purposes 1. Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence.

WHST.11-12.1. Write arguments focused on discipline-specific content.

WHST.11-12.1a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.

WHST.11-12.1b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audiences knowledge level, concerns, values, and possible biases.

WHST.11-12.1c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.

WHST.11-12.1d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

WHST.11-12.1e. Provide a concluding statement or section that follows from or supports the argument presented.

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

WHST.11-12.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

WHST.11-12.2a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.

WHST.11-12.2b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audiences knowledge of the topic.

WHST.11-12.2c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.

WHST.11-12.2d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.

WHST.11-12.2e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).

Production and Distribution of Writing 4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

WHST.11-12.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.

WHST.11-12.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

WHST.11-12.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

Research to Build and Present Knowledge 7. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

WHST.11-12.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.

WHST.11-12.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

Draw evidence from literary or informational texts to support analysis, reflection, and research.

WHST.11-12.9. Draw evidence from informational texts to support analysis, reflection, and research.

Range of Writing 10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

WHST.11-12.10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Reading: Science & Technical Subjects

Key Ideas and Details 1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

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.

Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.

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.

Analyze how and why individuals, events, or ideas develop and interact over the course of a text.

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 4. Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

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 1112 texts and topics.

Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole.

RST.11-12.5. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.

Assess how point of view or purpose shapes the content and style of a text.

RST.11-12.6. Analyze the authors 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 7. Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.

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.

Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.

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.

Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

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.

Read and comprehend complex literary and informational texts independently and proficiently.

RST.11-12.10. By the end of grade 12, read and comprehend science/technical texts in the grades 1112 text complexity band independently and proficiently.

Capacities of the Literate Individual

Students Who are College and Career Ready in Reading, Writing, Speaking, Listening, & Language

They demonstrate independence.

Catholic Identity

DOC All Grades Catholic Identity

Catholic Social Justice Teachings

Life and Dignity of the Human Person

Rights and Responsibilities

The Dignity of Work and the Rights of Workers

Call to Family, Community, and Participation

Option for the Poor and Vulnerable

Solidarity

Care for God's Creation

The Rights of Children

1. THE RIGHT TO A CATHOLIC COMMUNITY that witnesses to Christ and the Gospel by protecting them from child abuse, including sexual abuse and neglect.

2. THE RIGHT TO A SAFE ENVIRONMENT that promotes care, protection, and security.

3. THE RIGHT TO BE RESPECTED AS INDIVIDUALS with human dignity.

4. THE RIGHT TO WORK ACTIVELY TOWARD THEIR OWN EMPOWERMENT through the development of their gifts and talents.

5. THE RIGHT TO A LEARNING ENVIRONMENT THAT VALUES COOPERATION and challenges its members to critical and reflective thinking in their search for truth.

6. THE RIGHT TO DEVELOP POSITIVE, RESPONSIBLE AND CARING ATTITUDES AND BEHAVIORS TOWARD OTHERS and to recognize the rights of others to be safe and free from harassment and abuse.

7. THE RIGHT TO LEARN THE SKILL OF SELF PROTECTION by identifying safe and unsafe situations.

8. THE RIGHT TO LEARN RESPONSIBILITY for themselves and their actions.

9. THE RIGHT TO MAKE RESPONSIBLE DECISIONS founded on religious conviction.

10. THE RIGHT TO GUIDANCE FROM THE CHURCH in their development as loving people.

Summary

In this unit students will investigate the interactions between particles. Intramolecular forces hold atoms and ions together in compounds. Intermolecular forces hold molecules together and directly affect the macroscopic properties of matter including phase, melting and boiling point, solubility, and vapor pressure. This unit also asks students to use the language of chemistry in writing chemical formulas, naming compounds and using various models to represent compounds.

Unit Goals

1. Students will understand how atoms and/or ions come together to form compounds.
2. Students will understand the attractive and repulsive forces at work in chemical bonding.
3. Students will understand how to use naming conventions correctly.
4. Students will understand how to represent compounds with chemical formulas and chemical models.
5. Students will understand the similarities and differences between types of intramolecular forces: ionic, covalent and polar covalent.
6. Students will understand the similarities and differences between types of intermolecular forces: van der Waals forces, dipole interactions, dispersion forces, hydrogen bonds.
7. Students will understand how energy is transferred in phase changes.
8. Students will understand that bonds form to reduce the energy of the system.
9. Students will understand how models are used to represent compounds.
10. Students will understand how intermolecular forces determine melting point, boiling point, and vapor pressure.

Big Ideas

1. Atomic structure dictates the properties and interactions of matter
2. Energy occurs in different forms and is necessary to do work or to cause change.

Enduring Understandings

1. Matter has properties related to its structure that can be measured and used to identify, classify, and describe substances or objects.
2. Elements come together in specific ways to form compounds.
3. Names and models contain information about the structure of the compound.
4. Attractive and repulsive forces act on particles and compounds.
5. Phase can be altered by adding or removing energy from a substance.

Content

**Intramolecular Chemical Bonding: Ionic, Polar/Covalent**

1. Electron configurations, electronegativity values and energy considerations can be applied to bonding and the properties of materials with different types of bonding.
2. Energy is released to the surroundings when atoms bond, resulting in a system with lower energy.
3. Electron configurations and valence electrons determine how atoms interact with other atoms.
4. Molecules, ionic lattices and network covalent structures have different, yet predictable, properties that depend on the identity of the elements and the types of bonds formed.
5. Differences in electronegativity values can be used to predict where a bond fits on the continuum between ionic and covalent bonds.
6. The polarity of a bond depends on the electronegativity difference between the bonded elements.
7. Polar covalent bonds have properties between those of ionic and pure covalent bonds.
8. Properties of metals can be explained by metallic bonding.
9. Carbon atoms form many kinds of bonds:

Carbon atoms can bond together.

Carbon atoms can bond with other atoms, especially hydrogen, oxygen, nitrogen, and sulfur.

Carbon containing compounds can form chains, rings, and branching networks.

Carbon containing compounds are important components of synthetic polymers, fossil fuels, and the large molecules essential to life.

**Representing Compounds**

**Formula Writing and Nomenclature**

1. Using the periodic table, formulas of ionic compounds containing specific elements can be predicted.
2. Ionic compounds can be made up of elements from groups 1, 2, 17, hydrogen, oxygen and polyatomic ions.
3. Given the formula, a compound can be named using conventional systems that include Greek prefixes and Roman numerals where appropriate.
4. Given the name of an ionic or covalent substance, formulas can be written.

**Models and Shapes (Lewis Structures, Ball and Stick, Molecular Geometries)**

1. Many different models can be used to represent compounds including chemical formulas, Lewis structures, and ball and stick models.
2. Models can be used to visualize atoms and molecules and to predict the properties of substances.
3. There are strengths and weaknesses of different models representing compounds.
4. Lewis structures can be drawn to represent covalent compounds.
5. Valence shell electron pair repulsion (VSEPR) can be combined with Lewis structures to predict the three-dimensional electron pair and molecular geometry of compounds containing combinations of the following elements:

hydrogen

carbon

nitrogen

oxygen

phosphorus

sulfur

the halogens

**Quantifying Matter**

1. Mass can reflect the number of particles present.
2. The mole is used to translate between the atomic and macroscopic levels.
3. A mole is a counting number, like a dozen.
4. The mass of one mole of a substance is equal to its formula mass in grams.
5. The formula mass for a substance can be used in conjunction with Avogadro's number and the density of a substance to convert between mass, moles, volume, and number of particles of a sample.

**Phases of Matter**

1. Phase is related to the spacing of the particles, motion of the particles, and strength of attraction between the particles that make up the substance.
2. Plasmas occur when gases have so much energy that the electrons are stripped away; therefore, they are electrically charged.
3. In Bose-Einstein condensation, the atoms, when subjected to temperatures a few billionths of a degree above absolute zero, all coalesce to lose individual identity and become a "super atom."
4. Intermolecular chemical bonding details the forces of attraction between particles that determine whether a substance is a solid, liquid, or gas at room temperature.

**Intermolecular Chemical Bonding**

**Types and Strengths**

1. Intermolecular attractions are generally weak when compared to intramolecular bonds, but span a wide range of strengths.
2. The type and strength of bonding and intermolecular interactions are dependent on the composition of a substance and the shape and polarity of the molecule.
3. Types of intermolecular attractions, each with its own characteristic relative strengths, include:

London dispersion forces (present between all molecules)

dipole-dipole forces (present between polar molecules)

hydrogen bonding (a special case of dipole-dipole where hydrogen is bonded to highly electronegative atoms such as fluorine, oxygen or nitrogen)

1. The configuration of atoms in a molecule determines the strength of the forces between particles and, therefore, the physical properties of a material.
2. For a substance, the average kinetic energy (and therefore the temperature) needed for a change of state to occur depends upon the strength of the intermolecular forces between the particles.

**Implications for Properties of Substances:**

**Melting and Boiling Point**

1. The melting point and boiling point depend upon the amount of energy that is needed to overcome the attractions between the particles.
2. Substances that have strong intermolecular forces or are made up of three-dimensional networks of ionic or covalent bonds tend to be solids at room temperature and have high melting and boiling points.
3. Non-polar organic substances with longer chains provide more opportunities for weak London dispersion forces and tend to have higher melting and boiling points.
4. Increased branching of organic molecules interferes with the intermolecular attractions that lead to lower melting and boiling points.

**Solubility**

1. Substances will have a greater solubility when dissolving in a solvent with similar intermolecular forces.
2. Substances with different intermolecular forces are more likely to interact with themselves than another substance and, therefore, remain separated from each other.
3. Water is a polar molecule and is a common solvent for ionic and polar covalent substances.
4. Ionic substances dissolve in water when the attractive forces between the ions are overcome by the dipole-dipole interactions with water.

**Vapor pressure**

1. Evaporation occurs when the particles with enough kinetic energy to overcome the attractive forces separate from the rest of the sample to become a gas.
2. Vapor pressure is due to particles leaving the liquid phase and entering the gas phase and increases with temperature.
3. Particles with larger intermolecular forces have lower vapor pressure at a given temperature due to the stronger attractive forces between them.
4. Molecular substances often evaporate due to weak attractions between particles and can be detected by their odor (volatile substances).
5. Ionic or network covalent substances have stronger intermolecular forces, are not likely to volatilize, and often have little if any odor.
6. Liquids boil when their vapor pressure is equal to atmospheric pressure.
7. Water expands as it freezes, and solid water has a lower density than liquid water due to the structure formed by hydrogen bonds between particles.

**Stoichiometry: Molar Calculations, Solutions**

1. Molarity is a measure of the concentration of a solution.

Adapted from Ohio Revised Science Standards and Model Curriculum

Resources

* Ohio Revised Science Standards and Model Curriculum (<http://education.ohio.gov/getattachment/Topics/Ohio-s-New-Learning-Standards/Science/HSscience_Model_Curriculum_April2014-1.pdf.aspx>)

Skills

**Bloom's Taxonomy/DOK**

**Remember (Level 1)**

1. Compare plasmas and Bose-Einstein condensates to more familiar phases (plasmas are super-hot atoms, Bose-Einstein condensates are super-cold atoms).
2. Compare the characteristic relative strengths of intermolecular attractions.

**Understand (Level 1 and 2)**

1. Determine the number of valence electrons in an atom of a representative element.
2. Explain how ions form.
3. Explain properties of metals using metallic bonding.
4. Write formulas of ionic or covalent substances.
5. Name compounds using conventional systems that include Greek prefixes and Roman numerals where appropriate.
6. Use models to visualize atoms and molecules.
7. Explain the characteristic relative strengths of intermolecular attractions.
8. Explain boiling point in terms of intermolecular forces.
9. Explain why some substances have detectable odors and others do not.
10. Explain why water expands as it freezes.
11. Explain why solid water is less dense than liquid water.

**Analyze (Level 3)**

1. Model the valence electrons of metal atoms.
2. Apply the octet rule to forming chemical compounds and explain some exceptions to the octet rule.
3. Draw Lewis structures to represent covalent compounds.
4. Determine the strength and type of bonding and intermolecular interactions by analyzing the composition of the substance and the shape and polarity of the molecule.
5. Determine the strength of the forces between particles due to the configuration of atoms in a molecule.
6. Determine the physical properties of a material due to the strength and types of forces between particles.
7. Compare the temperature needed for a change of state to occur for different substances.
8. Compare vapor pressure of substances based on intermolecular forces.
9. Explain why the properties of water have significant implications for life.
10. Calculate the concentration of a solution (molarity).

**Evaluate (Level 3 and Level 4)**

1. Evaluate differences in boiling point, melting point, vapor pressure, etc. due to different intermolecular forces.
2. Predict the properties of molecules, ionic lattices, and network covalent structures based on the identity of the elements and the types of bonds formed.
3. Use differences in electronegativity values to predict where a bond fits on the continuum between ionic and covalent bonds.
4. Predict polarity of a bond based on the electronegativity difference and the distance between the atoms.
5. Predict the formulas of ionic compounds containing specific elements using the periodic table.
6. Predict the formula of ionic compounds made up of elements from groups 1, 2, 17, hydrogen, oxygen, and polyatomic ions.
7. Predict the properties of substances using models.
8. Predict three-dimensional electron pair and molecular geometry of compounds using valence shell electron pair repulsion and Lewis structures.
9. Compare melting points and boiling points for different substances and relate the differences to attractions between the particles.
10. Predict the solubility of substances based on the types of intermolecular forces between solvent and solute.

**Create (Level 4)**

1. Create models to represent compounds including chemical formulas, Lewis structures, and ball and stick models.

Essential Questions

1. What role do electrons play in chemical bonding?
2. How do the properties of ionic, covalent, and metallic compounds differ?
3. How is the bonding in molecular compounds different from the bonding in ionic compounds?
4. How do electrons affect the shape of a molecule?
5. What factors affect molecular properties?
6. Why is water liquid at room temperature?
7. Why does ice float in water?
8. How does the periodic table help us determine the names and formulas of ions and compounds?
9. How do the interactions between water molecules account for the unique properties of water?
10. How do aqueous solutions form?
11. How can the concentration of solutions be measured?

Stage 2: Assessment Evidence

Bond with a Classmate

Formative: Cooperative Group Work

Students each receive a name tag with an ion. They must then find other students to bond with and document the correct formula and name of the ionic compound formed.

Lewis Structure Lab

Formative: Lab Assignment

Students draw and analyze Lewis structures for ionic and covalent compounds.

VSEPR Lab

Formative: Lab Assignment

Students create and analyze 3D models of molecules according to VSEPR theory.

Oleic Acid Lab (measuring the thickness of a molecule)

Formative: Lab Assignment

Students use indirect measuring methods to determine the thickness of a single molecule of oleic acid.

Determining the Concentration of a Solution: Beer's Law

Formative: Lab Assignment

Lab from Chemistry with Vernier.

Evaporation and Intermolecular Attractions

Formative: Lab Assignment

Lab from Chemistry with Vernier.

Physical Properties of Water

Formative: Lab Assignment

Guided Inquiry lab from Investigating Chemistry through Inquiry from Vernier.

Vapor Pressure and Heat of Vaporization Investigations

Formative: Lab Assignment

Guided Inquiry lab from Investigating Chemistry through Inquiry from Vernier. (Link is to lab manual; scroll down to table of contents.)

POGIL activities

Formative: Cooperative Group Work

Naming Ionic CompoundsPolyatomic IonsNaming Molecular CompoundsNaming AcidsMolecular GeometrySaturated and Unsaturated SolutionsSolubilityMolarity

Laboratory Work

Formative: Lab Assignment

Teachers can assign labs from the laboratory manual, create their own labs, or use labs from web sources, many of which are listed in the reference section. Laboratory exercises are a necessary part of high school science; however, not all schools have the same equipment, so any variety of labs may be used to aid students in their understanding of unit concepts. They can be formative, exploring a new concept, or summative, showing a practical application of concept knowledge.

Lab Report

Summative: Writing Assignment

Following a laboratory investigation, the student analyzes the data collected, applies concepts to real life situations, and synthesizes information from the lab, class discussions, and additional research into a formal lab report. RERUN Recall what you did in lab. Explain how your hypothesis was supported or not supported by your data. Results: Organize data in a logical and appropriate manner such as chart, graph, etc. Unexpected results: Explain all errors and/or unexpected results. New things learned must be articulated clearly and completely.

Graphic Organizer

Formative: Graphic Organizer

Students make connections between concepts.

Homework Problems

Formative: Homework

Students solve problems involving chemical bonding and representing compounds.

Quizzes

Formative: Quiz

Quizzes are used to gauge the progress of student understanding of learning content and skills.

White Board Races

Formative: Cooperative Group Work

Students work in pairs to answer questions presented to the class. Student pairs must show all work on individual white boards which they hold up for immediate feedback. More whiteboarding strategies are described in the link.

Unit Test

Summative: Test

Unit Test

Resources

Stage 3: Learning Plan

Learning Experiences

1. Guided Inquiry
2. Cooperative Learning Groups
3. POGIL Activities
4. Graphic Organizers
5. Small Group and Class Discussions
6. Direct Instruction
7. Critical Thinking

Resources

* <https://pogil.org/about>

Technology Integration

1. Smart Board
2. Smart phone
3. Chromebooks, Computers Internet
4. Graphing software (Excel, LoggerPro)
5. Vernier software and hardware
6. Pasco software and hardware
7. iPad apps
8. Phet simulations
9. LCD projector
10. PowerPoint
11. Internet resources
12. Online video clips

Resources

**Books**

1. Trout, L. (2012). *POGIL activities for high school chemistry*. Batavia, IL: Flinn Scientific, Inc.
2. Wilbraham, A., et al. (2012). *Chemistry.* New York: Pearson.
3. Timberlake, K., and Timberlake, W. (2008). *Basic chemistry*, 2nd edition. New York: Prentice Hall.
4. Buthelezi,T., Dingrando, L., Hainen, N. (2008). *Chemistry: Matter and change. New York:* Glencoe, 2008.
5. Volz, D.L., and Smola, R. (2009). *Investigating chemistry through inquiry*. Beaverton, OR: Vernier.
6. Holmquist, D.D., Randall, J., and Volz, D.L. (2007). *Chemistry with Vernier.* Beaverton, OR: Vernier.

Resources

* <http://www.flinnsci.com/teacher-resources/chemistry/>

Grades 9-12 Science  
Chemistry

Chemical Reactions

Stage 1: Desired Results

Catholic Standards

DOC All Grades DOC: Catholic Standards

The Profession of Faith

Students will be able to

1. Recognize God in the world's order, beauty, and goodness (CCC 32).

Life in Christ

Students will be able to

2. Know that we must assume responsibility for the acts we perform (CCC 1781).

12. Respect the integrity of all creation, including animals, plants, and all nature (CCC 2415).

Targeted Standards

NGSS Grade 9-12 NGSS: Science and Engineering Practices

Practice 8. Obtaining, evaluating, and communicating information

Obtaining, evaluating, and communicating information in 912 builds on K8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order 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 usefulness of each source.

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Practice 6. Constructing explanations (for science) and designing solutions (for engineering)

Constructing explanations and designing solutions in 912 builds on K8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.

Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Practice 7. Engaging in argument from evidence

Engaging in argument from evidence in 912 builds on K8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.

Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Practice 1. Asking questions (for science) and defining problems (for engineering)

Asking questions and defining problems in 912 builds on K8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.

Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.

Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.

Ask questions to clarify and refine a model, an explanation, or an engineering problem.

Evaluate a question to determine if it is testable and relevant.

Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.

Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.

Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and/or environmental considerations.

Practice 2. Developing and using models

Modeling in 912 builds on K8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria.

Design a test of a model to ascertain its reliability.

Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.

Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Practice 3. Planning and carrying out investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigations design to ensure variables are controlled.

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.

Select appropriate tools to collect, record, analyze, and evaluate data.

Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.

Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

Practice 4. Analyzing and interpreting data

Analyzing data in 912 builds on K8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.

Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.

Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.

Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.

Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Practice 5. Using mathematics and computational thinking

Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Apply techniques of algebra and functions to represent and solve scientific and engineering problems.

Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model makes sense by comparing the outcomes with what is known about the real world.

Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).

OH Grade 9-12 OH: Science (2011)

HS Chemistry

Science Inquiry and Application During the years of grades 9 through 12 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

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 defend a scientific argument.

Course Content: Structure and Properties of Matter

Representing compounds: Formula writing

Representing compounds: Nomenclature

Course Content: Interactions of Matter

Chemical reactions: Types of reactions

Chemical reactions: Kinetics

Chemical reactions: Energy

Chemical reactions: Equilibrium

Chemical reactions: Acids/bases

OH Grades 11-12 OH: Literacy in History/Social Studies, Science, & Technical Subjects 6-12

Writing

Text Types and Purposes 1. Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence.

WHST.11-12.1. Write arguments focused on discipline-specific content.

WHST.11-12.1a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.

WHST.11-12.1b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audiences knowledge level, concerns, values, and possible biases.

WHST.11-12.1c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.

WHST.11-12.1d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

WHST.11-12.1e. Provide a concluding statement or section that follows from or supports the argument presented.

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

WHST.11-12.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

WHST.11-12.2a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.

WHST.11-12.2b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audiences knowledge of the topic.

WHST.11-12.2c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.

WHST.11-12.2d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.

WHST.11-12.2e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).

Production and Distribution of Writing 4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

WHST.11-12.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.

WHST.11-12.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

WHST.11-12.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

Research to Build and Present Knowledge 7. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

WHST.11-12.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.

WHST.11-12.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

Draw evidence from literary or informational texts to support analysis, reflection, and research.

WHST.11-12.9. Draw evidence from informational texts to support analysis, reflection, and research.

Range of Writing 10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

WHST.11-12.10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Reading: Science & Technical Subjects

Key Ideas and Details 1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

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.

Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.

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.

Analyze how and why individuals, events, or ideas develop and interact over the course of a text.

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 4. Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

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 1112 texts and topics.

Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole.

RST.11-12.5. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.

Assess how point of view or purpose shapes the content and style of a text.

RST.11-12.6. Analyze the authors 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 7. Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.

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.

Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.

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.

Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

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.

Read and comprehend complex literary and informational texts independently and proficiently.

RST.11-12.10. By the end of grade 12, read and comprehend science/technical texts in the grades 1112 text complexity band independently and proficiently.

Capacities of the Literate Individual

Students Who are College and Career Ready in Reading, Writing, Speaking, Listening, & Language

They demonstrate independence.

Catholic Identity

DOC All Grades Catholic Identity

Catholic Social Justice Teachings

Life and Dignity of the Human Person

Rights and Responsibilities

The Dignity of Work and the Rights of Workers

Call to Family, Community, and Participation

Option for the Poor and Vulnerable

Solidarity

Care for God's Creation

The Rights of Children

1. THE RIGHT TO A CATHOLIC COMMUNITY that witnesses to Christ and the Gospel by protecting them from child abuse, including sexual abuse and neglect.

2. THE RIGHT TO A SAFE ENVIRONMENT that promotes care, protection, and security.

3. THE RIGHT TO BE RESPECTED AS INDIVIDUALS with human dignity.

4. THE RIGHT TO WORK ACTIVELY TOWARD THEIR OWN EMPOWERMENT through the development of their gifts and talents.

5. THE RIGHT TO A LEARNING ENVIRONMENT THAT VALUES COOPERATION and challenges its members to critical and reflective thinking in their search for truth.

6. THE RIGHT TO DEVELOP POSITIVE, RESPONSIBLE AND CARING ATTITUDES AND BEHAVIORS TOWARD OTHERS and to recognize the rights of others to be safe and free from harassment and abuse.

7. THE RIGHT TO LEARN THE SKILL OF SELF PROTECTION by identifying safe and unsafe situations.

8. THE RIGHT TO LEARN RESPONSIBILITY for themselves and their actions.

9. THE RIGHT TO MAKE RESPONSIBLE DECISIONS founded on religious conviction.

10. THE RIGHT TO GUIDANCE FROM THE CHURCH in their development as loving people.

Summary

In this unit students will continue to use the skills of writing formulas and naming compounds developed previously in the course. Students have developed understanding of the forces that hold atoms and ions together in compounds in previous units, and in this unit students will analyze how these bonds can be broken and reformed in chemical reactions. Students will develop understanding of how to classify chemical reactions and predict the products of chemical reactions. Students will analyze the energy transfers that accompany chemical reactions as bonds break and are reformed. Students will explore the factors that control the speed of chemical reactions through kinetics and the factors that control the extent to which reactions proceed through equilibrium. Acid/Base chemistry is a very important example of chemical reactions and has many practical applications.

Unit Goals

1. Students will understand how to use compound naming and formula writing conventions correctly.
2. Students will understand how conservation of matter applies to balancing chemical reactions.
3. Students will understand how chemical reactions can be classified.
4. Students will understand the factors that affect the rates of chemical reactions (kinetics).
5. Students will understand how energy can be released or absorbed in a chemical process.
6. Students will understand how energy is conserved in chemical reactions.
7. Students will understand the factors that affect the extent to which a chemical reaction proceeds (equilibrium).
8. Students will understand the difference between product-favored and reactant-favored reactions (equilibrium).
9. Students will understand what the pH of a solution means and how to calculate pH.
10. Students will understand the role of hydrogen ions (hydronium ions) and hydroxide ions in acid/base reactions.

Big Ideas

Matter and energy are conserved in chemical reactions.

Enduring Understandings

1. Chemical reactions occur all around us and may either release or consume energy.
2. Atoms are not created or destroyed in a chemical reaction.
3. In a chemical reaction, atoms are rearranged.
4. The products of a chemical reaction can be predicted following common patterns in reactions.
5. For a reaction to occur, the reactants must collide with sufficient energy and with the correct orientation.
6. The speed of a reaction can be affected by temperature, concentration or pressure, and catalysts.
7. Reactions can occur in both the forward and backward direction (dynamic equilibrium).
8. Acids and bases react together in neutralization reactions.
9. pH measures the hydrogen ion (hydronium ion) concentration of a solution.

Content

**Representing Compounds: Formula Writing, Nomenclature, Models**

1. Using the periodic table, formulas of ionic compounds containing specific elements can be predicted.
2. Ionic compounds can be made up of elements from groups 1, 2, 17, hydrogen, oxygen and polyatomic ions.
3. Given the formula, a compound can be named using conventional systems that include Greek prefixes and Roman numerals where appropriate.
4. Given the name of an ionic or covalent substance, formulas can be written.

**Chemical Reactions**

**Types of Reactions**

1. Complex reactions can be studied, classified and represented with chemical equations and three-dimensional models.
2. Classifying reactions into types is a helpful organizational tool in recognizing patterns of reactions.
3. Some general types of chemical reactions are oxidation/reduction, synthesis, decomposition, single-replacement, double replacement (including precipitation reaction and some acid base reactions), and combustion reactions.
4. Organic molecules release energy when undergoing combustion reaction and are used to meet the energy needs of society (oil, gasoline, natural gas, etc.) and biological organisms (cellular respiration).
5. Precipitation reactions (or reactions that result in the formation of a molecular compound) occur because the new ionic or covalent bonds are stronger than the original ion-dipole interactions of the ions in solution.

**Kinetics**

1. Reactions occur when reacting particles collide in an appropriate orientation and with sufficient energy.
2. Not all collisions are effective.
3. Activation energy is required to initiate a reaction with stable reactants.
4. A catalysis provides an alternate pathway for a reaction, usually with a lower activation energy which causes more collisions to have enough energy to result in a reaction.
5. An enzyme is a large organic molecule that folds into a unique shape by forming intermolecular bonds with itself.
6. The enzyme's shape allows it to hold a substrate molecule in the proper orientation to result in an effective collision.
7. The rate of a chemical reaction is the change in the amount of reactants or products in a specific period of time.
8. Increasing the probability or effectiveness of the collisions between the particles increases the rate of the reaction.
9. Reaction rate is affected by the concentration of the reactants, the temperature or the pressure of gaseous reactants.
10. Collision theory can be applied to dissolving solids in a liquid solvent.
11. Collision theory can be used to explain why reactions are more likely to occur between reactants in the aqueous or gaseous state than between solids.
12. Kinetic-molecular theory can be used to help visualize reactions.

**Energy**

1. In chemical systems, potential energy is in the form of chemical energy, and kinetic energy is in the form of thermal energy.
2. The energy change of a system can be calculated from measurements (mass and change in temperature) from calorimetry experiments in the laboratory.
3. Conservation of energy is an important component of calorimetry equations.
4. Thermal energy is the energy of a system due to the movement (translational, vibrational, and rotational) of its particles.
5. The thermal energy of an object depends upon the amount of matter present (mass), temperature and chemical composition.
6. Specific heat is a measure of how much energy is needed to change the temperature of a specific mass of material by a specific amount.
7. Specific heat values can be used to calculate the thermal energy change, the temperature (initial, final or change in) or mass of a material in calorimetry.
8. Water has a particularly high specific heat capacity, which is important in regulating Earth's temperature.
9. Chemical reactions involve valence electrons forming bonds to yield more stable products with lower energies.
10. Energy is required to break interactions and bonds between the reactant atoms, and energy is released when an interaction or bond is formed between the atoms in the products.
11. Energy is transferred out of the system (exothermic) when the products have stronger bonds than the reactants and is transferred into the system (endothermic) when the reactants have stronger bonds than the products.
12. Predictions of the energy requirements (endothermic or exothermic) of a reaction can be made given a table of bond energies.
13. Graphic representations can be drawn and interpreted to represent the energy changes during a reaction, including the activation energy.
14. Energy and entropy can be used to determine the spontaneity of chemical reactions.

**Equilibrium**

1. All reactions are reversible to a degree, and many reactions do not proceed completely toward products but appear to stop progressing before reactants are all used up.
2. Amounts of reactants and products can appear to be constant and exist in a state of dynamic equilibrium.
3. At equilibrium the rate of the reverse reaction is equal to the rate of the forward reaction, so there is no apparent change in the reaction.
4. If a reaction appears to proceed only in one direction, the reverse reaction can occur, but is highly unlikely.
5. Reactions that appear to proceed only in one direction usually release large amounts of energy and require a large input of energy to go in the reverse direction.
6. If a chemical system at equilibrium is disturbed by a change in the conditions of the system (e.g., increase or decrease in the temperature, pressure on gaseous equilibrium systems, concentration of a reactant or product), then the equilibrium system will respond by shifting to a new equilibrium state, reducing the effect of the change (Le Chatelier's Principle).
7. An unfavorable reaction can be made to occur by removing products as they are formed during a reaction, forcing the equilibrium position of the system to shift to favor the products.
8. Computer simulations can help visualize the progression of a reaction to dynamic equilibrium and then continuation of both the forward and reverse reactions after equilibrium has been attained.

**Acids/bases**

1. Structural features of molecules are used to explain acids and bases.
2. Acids often result when hydrogen is covalently bonded to an electronegative element and is easily dissociated from the rest of the molecule to bind with water to form a hydronium ion.
3. The acidity of an aqueous solution can be expressed as pH, where pH can be calculated from the concentration of the hydronium ion.
4. Bases are likely to dissociate in water to form a hydroxide ion.
5. Acids can react with bases to form a salt and water.
6. Neutralization reactions can be studied quantitatively by performing titration experiments.

Adapted from Ohio Revised Science Standards and Model Curriculum

Resources

* <http://education.ohio.gov/getattachment/Topics/Ohio-s-New-Learning-Standards/Science/HSscience_Model_Curriculum_April2014-1.pdf.aspx>

Skills

**Bloom's Taxonomy/DOK**

**Remember (Level 1)**

1. Write formulas for ionic and covalent compounds.
2. Name ionic and covalent compounds.
3. Explain how energy released from combustion is used by society or organisms.
4. Explain how energy is released from combustion of organic molecules.
5. Explain the role of activation energy in reactions.

Explain the effects of a catalyst on a reaction.

Explain the role and effects of an enzyme in chemical reactions in a biological system.

**Understand (Level 1 and 2)**

1. Apply naming conventions and formula writing to reactions.
2. Calculate molarity.
3. Classify and represent complex reactions with chemical equations and three-dimensional models.
4. Classify reactions into types based on chemical similarities and/or surface features (oxidation/reduction, synthesis, decomposition, single replacement, double replacement [including precipitation reaction and some acid base reactions] combustion, etc.).
5. Identify reactions involving oxidation and reduction and indicate what substance is being oxidized and what is being reduced.
6. Write and balance reactions that result in precipitates or molecular compounds.
7. Explain that the driving force between precipitation reactions is that the new bonds formed are stronger than the original ion-dipole interactions of the ions in solution.
8. Explain the process of dissolving solids in a liquid solvent using collision theory.
9. Use collision theory to explain why reactions are more likely to occur between reactants in the aqueous or gaseous state than between solids.
10. Calculate specific heat for a material.
11. Explain how valence electrons are involved in chemical reactions.
12. Explain dynamic equilibrium.
13. Calculate pH of an aqueous solution.

**Analyze (Level 3)**

1. Perform laboratory experiences (3-D or virtual) with different types of chemical reactions.
2. Determine the change in energy of a system through calorimetry experiments.
3. Calculate variables in calorimetry making use of conservation of energy.
4. Use specific heat to calculate the thermal energy change, temperature, or mass of a material in calorimetry.
5. Predict the energy requirements (endothermic or exothermic) of a reaction when given a table of bond energies.
6. Use computer simulations to help visualize reactions from the perspective of the kinetic-molecular theory.
7. Use computer simulations to help visualize the progression of a reaction to dynamic equilibrium and observe the system at dynamic equilibrium.
8. Use the structure of a substance to determine if the compound is an acid.
9. Write neutralization reactions in which an acid and a base react to form a salt and water.

**Evaluate (Level 3 and Level 4)**

1. Predict if a reaction will occur according to collision theory.
2. Predict the effect of changing temperature, pressure of gas phase reactants, or concentration of reactants on the rate of reaction.
3. Draw graphic representations to illustrate the energy changes during a reaction, including the activation energy.

Determine the spontaneity of chemical reactions using the concepts of energy and entropy.

Determine the equilibrium concentrations and the time at which equilibrium was established when given a graph showing the concentration of the reactants and products over the time of reaction.

1. Predict the effect of a disturbance on an equilibrium system (Le Chatelier's Principle).
2. Perform titration experiments to study neutralization reactions quantitatively.

**Create (Level 4)**

1. Design a procedure for a titration experiment.
2. Design a change to a system in order to force an unfavorable reaction to occur.

Essential Questions

1. How do chemical compounds interact in chemical reactions?
2. How do chemical reactions obey the law of conservation of mass?
3. How can we predict the products of a chemical reaction?
4. How is energy conserved in a chemical or physical process?
5. Why do some reactions increase the temperature of the system while other reactions decrease the temperature of the system?
6. How can the rate of a chemical reaction be controlled?
7. Why do only some reactions occur spontaneously?
8. Why don't all reactions proceed to completion?
9. What does the pH of a solution mean and why does pH need to be controlled in some situations (swimming pools, blood, etc.)?

Stage 2: Assessment Evidence

Exploring Chemical Change

Formative: Lab Assignment

Students work through this station lab to make observations of 5 different types of chemical reactions.

Endothermic and Exothermic Reactions

Formative: Lab Assignment

Lab from Chemistry with Vernier. (See Link to lab manual; scroll down to table of contents.)

Energy Content of Foods

Formative: Lab Assignment

Lab from Chemistry with Vernier. (See Link to the lab manual; scroll down to the table of contents.)

Reaction Rates

Formative: Lab Assignment

Guided Inquiry lab from Investigating Chemistry through Inquiry. (See Link to lab manual; scroll down to table of contents.)

Enzyme Activity

Formative: Lab Assignment

Guided Inquiry lab from Investigating Chemistry through Inquiry. (See Link to lab manual; scroll down to table of contents.)

Chemical Equilibrium: Finding a Constant, Kc

Formative: Lab Assignment

Lab from Chemistry with Vernier (See Link to lab manual; scroll down to table of contents.)

Acid-Base Titration

Formative: Lab Assignment

Lab from Chemistry with Vernier. (see Link to lab manual; scroll down to table of contents.)

POGIL Activities

Formative: Cooperative Group Work

Types of Chemical ReactionsCalorimetryBond EnergyEquilibriumAcids and BasesStrong versus Weak AcidsCalculating pHOxidation and Reduction

Laboratory Work

Formative: Lab Assignment

Teachers can assign labs from the laboratory manual, create their own labs, or use web sources, many of which are listed in the reference section. Laboratory exercises are a necessary part of high school science; however not all schools have the same equipment, so any variety of labs may be used to aid students in their understanding of unit concepts. They can be formative, exploring a new concept, or summative, showing a practical application of concept knowledge.

Lab Report

Summative: Writing Assignment

Following a laboratory investigation, the student analyzes the data collected, applies concepts to real life situations, and synthesizes information from the lab, class discussions, and additional research into a formal lab report. RERUN Recall what you did in lab. Explain how your hypothesis was supported or not supported by your data. Results: Organize data in a logical and appropriate manner such as chart, graph, etc. Unexpected results: Explain all errors and/or unexpected results. New things learned must be articulated clearly and completely.

Graphic Organizer

Formative: Graphic Organizer

Students make connections between concepts using graphic organizer.

Homework Problems

Formative: Homework

Students solve problems involving chemical reactions.

Quizzes

Formative: Quiz

Quizzes are used to gauge the progress of student understanding of learning content and skills.

White Board Races

Formative: Cooperative Group Work

Students work in pairs to answer questions presented to the class. Student pairs must show all work on individual white boards which they hold up for immediate feedback. More whiteboarding strategies are described in the link.

Unit Test

Summative: Test

Unit Test

Resources

Stage 3: Learning Plan

Learning Experiences

1. Guided Inquiry
2. Cooperative Learning Groups
3. POGIL Activities
4. Graphic Organizers
5. Small Group and Class Discussions
6. Direct Instruction
7. Critical Thinking
8. Career Connection: What can you do with a degree in chemistry?

Career opportunities range from research, medicine, engineering, technology, materials science, manufacturing, environmental work, food production, art, and even law. Research these opportunities at the American Chemical Society website listed in Resources.

Resources

* <https://pogil.org/about>

Technology Integration

1. Smart Board
2. Smart phone
3. Chromebooks, computers Internet
4. Graphing software (Excel, LoggerPro)
5. Vernier software and hardware
6. Pasco software and hardware
7. iPad apps
8. Phet simulations
9. LCD projector
10. PowerPoint
11. Internet resources
12. Online video clips

Resources

**Books**

1. Trout, L. (2012). *POGIL activities for high school chemistry*. Batavia, IL: Flinn Scientific, Inc.
2. Wilbraham, A., et al. (2012). *Chemistry.* New York: Pearson.
3. Timberlake, K., and Timberlake, W. (2008). *Basic chemistry*, 2nd edition. New York: Prentice Hall.
4. Buthelezi,T., Dingrando, L., Hainen, N. (2008). *Chemistry: Matter and change. New York:* Glencoe, 2008.
5. Volz, D.L., and Smola, R. (2009). *Investigating chemistry through inquiry*. Beaverton, OR: Vernier.
6. Holmquist, D.D., Randall, J., and Volz, D.L. (2007). *Chemistry with Vernier.* Beaverton, OR: Vernier.

Resources

* <http://phet.colorado.edu/en/simulations/category/chemistry>

Grades 9-12 Science  
Chemistry

Stoichiometry

Stage 1: Desired Results

Catholic Standards

DOC All Grades DOC: Catholic Standards

The Profession of Faith

Students will be able to

1. Recognize God in the world's order, beauty, and goodness (CCC 32).

Life in Christ

Students will be able to

2. Know that we must assume responsibility for the acts we perform (CCC 1781).

12. Respect the integrity of all creation, including animals, plants, and all nature (CCC 2415).

Targeted Standards

NGSS Grade 9-12 NGSS: Science and Engineering Practices

Practice 8. Obtaining, evaluating, and communicating information

Obtaining, evaluating, and communicating information in 912 builds on K8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order 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 usefulness of each source.

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Practice 6. Constructing explanations (for science) and designing solutions (for engineering)

Constructing explanations and designing solutions in 912 builds on K8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.

Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Practice 7. Engaging in argument from evidence

Engaging in argument from evidence in 912 builds on K8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.

Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Practice 1. Asking questions (for science) and defining problems (for engineering)

Asking questions and defining problems in 912 builds on K8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.

Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.

Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.

Ask questions to clarify and refine a model, an explanation, or an engineering problem.

Evaluate a question to determine if it is testable and relevant.

Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.

Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.

Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and/or environmental considerations.

Practice 2. Developing and using models

Modeling in 912 builds on K8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria.

Design a test of a model to ascertain its reliability.

Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.

Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Practice 3. Planning and carrying out investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigations design to ensure variables are controlled.

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.

Select appropriate tools to collect, record, analyze, and evaluate data.

Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.

Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

Practice 4. Analyzing and interpreting data

Analyzing data in 912 builds on K8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.

Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.

Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.

Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.

Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Practice 5. Using mathematics and computational thinking

Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Apply techniques of algebra and functions to represent and solve scientific and engineering problems.

Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model makes sense by comparing the outcomes with what is known about the real world.

Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).

OH Grade 9-12 OH: Science (2011)

HS Chemistry

Science Inquiry and Application During the years of grades 9 through 12 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

Use technology and mathematics to improve investigations and communications;

Formulate and revise explanations and models using logic and evidence (critical thinking);

Course Content: Structure and Properties of Matter

Quantifying matter

Course Content: Interactions of Matter

Stoichiometry: Molar calculations

Stoichiometry: Solutions

Stoichiometry: Limiting reagents

OH Grades 11-12 OH: Literacy in History/Social Studies, Science, & Technical Subjects 6-12

Writing

Text Types and Purposes 1. Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence.

WHST.11-12.1. Write arguments focused on discipline-specific content.

WHST.11-12.1a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.

WHST.11-12.1b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audiences knowledge level, concerns, values, and possible biases.

WHST.11-12.1c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.

WHST.11-12.1d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

WHST.11-12.1e. Provide a concluding statement or section that follows from or supports the argument presented.

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

WHST.11-12.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

WHST.11-12.2a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.

WHST.11-12.2b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audiences knowledge of the topic.

WHST.11-12.2c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.

WHST.11-12.2d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.

WHST.11-12.2e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).

Production and Distribution of Writing 4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

WHST.11-12.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.

WHST.11-12.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

WHST.11-12.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

Research to Build and Present Knowledge 7. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

WHST.11-12.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.

WHST.11-12.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

Draw evidence from literary or informational texts to support analysis, reflection, and research.

WHST.11-12.9. Draw evidence from informational texts to support analysis, reflection, and research.

Range of Writing 10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

WHST.11-12.10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Reading: Science & Technical Subjects

Key Ideas and Details 1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

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.

Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.

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.

Analyze how and why individuals, events, or ideas develop and interact over the course of a text.

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 4. Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

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 1112 texts and topics.

Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole.

RST.11-12.5. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.

Assess how point of view or purpose shapes the content and style of a text.

RST.11-12.6. Analyze the authors 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 7. Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.

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.

Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.

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.

Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

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.

Read and comprehend complex literary and informational texts independently and proficiently.

RST.11-12.10. By the end of grade 12, read and comprehend science/technical texts in the grades 1112 text complexity band independently and proficiently.

Capacities of the Literate Individual

Students Who are College and Career Ready in Reading, Writing, Speaking, Listening, & Language

They demonstrate independence.

Catholic Identity

DOC All Grades Catholic Identity

Catholic Social Justice Teachings

Life and Dignity of the Human Person

Rights and Responsibilities

The Dignity of Work and the Rights of Workers

Call to Family, Community, and Participation

Option for the Poor and Vulnerable

Solidarity

Care for God's Creation

The Rights of Children

1. THE RIGHT TO A CATHOLIC COMMUNITY that witnesses to Christ and the Gospel by protecting them from child abuse, including sexual abuse and neglect.

2. THE RIGHT TO A SAFE ENVIRONMENT that promotes care, protection, and security.

3. THE RIGHT TO BE RESPECTED AS INDIVIDUALS with human dignity.

4. THE RIGHT TO WORK ACTIVELY TOWARD THEIR OWN EMPOWERMENT through the development of their gifts and talents.

5. THE RIGHT TO A LEARNING ENVIRONMENT THAT VALUES COOPERATION and challenges its members to critical and reflective thinking in their search for truth.

6. THE RIGHT TO DEVELOP POSITIVE, RESPONSIBLE AND CARING ATTITUDES AND BEHAVIORS TOWARD OTHERS and to recognize the rights of others to be safe and free from harassment and abuse.

7. THE RIGHT TO LEARN THE SKILL OF SELF PROTECTION by identifying safe and unsafe situations.

8. THE RIGHT TO LEARN RESPONSIBILITY for themselves and their actions.

9. THE RIGHT TO MAKE RESPONSIBLE DECISIONS founded on religious conviction.

10. THE RIGHT TO GUIDANCE FROM THE CHURCH in their development as loving people.

Summary

In previous units, students studied qualitative observations of chemical reactions. This unit develops the quantitative studies of chemical reactions. Students will use the coefficients of the balanced chemical equation to determine the ratios between the substances in the chemical reaction. The amount of reactants used in a chemical reaction or the amount of products produced can be determined in moles and then converted to mass, volume of a gas, volume of a solution, and/or number of particles. Molarity is used to describe the concentration of a solution.

Unit Goals

1. Students will understand how the mole is used to quantify particles.
2. Students will understand that matter is conserved in chemical reactions and that conservation can be mathematically quantified.
3. Students will understand that concentration of solutions can be quantified by molarity.
4. Students will understand the factors that influence solubility.
5. Students will understand the effects of limiting reactants on chemical reactions.
6. Students will understand that several factors affect experimental yield.
7. Students will understand the mathematical process of dimensional analysis.

Big Ideas

1. Matter and energy are conserved in chemical reactions.
2. Matter can be quantified in several ways.

Enduring Understandings

1. The mole is used to count large groups of tiny particles.
2. Amounts of reactants and products can be calculated from a balanced chemical equation.
3. Mass is conserved in chemical reactions.
4. Molarity quantifies the concentration of a solution.
5. Reactions can be limited by an insufficient quantity of any of the reactants.

Content

**Quantifying Matter**

1. scientific protocols for quantifying the properties of matter accurately and precisely
2. significant digits or figures
3. scientific notation
4. error analysis
5. dimensional analysis
6. procedures for measurements in macroscopic and submicroscopic domains
7. the mole

The mole is used to translate between the atomic and macroscopic levels.

The mass of one mole of a substance is equal to its formula mass in grams.

1. The formula mass for a substance can be used in conjunction with Avogadro's number and the density of a substance to convert between mass, moles, volume, and number of particles of a sample.
2. Mass can reflect the number of particles present.

**Stoichiometry: Molar Calculations, Solutions, Limiting Reagents**

1. A stoichiometric calculation involves the conversion from the amount of one substance in a chemical reaction to the amount of another substance.
2. The coefficients of the balanced chemical equation indicate the ratios of the substances involved in the reaction in terms of both particles and moles.
3. Once the number of moles of a substance is known, amounts can be changed to mass, volume of gas, volume of solutions and/or number of particles.
4. Molarity is a measure of the concentration of a solution that can be used in stoichiometric calculations.
5. The experimental yield can be compared to the theoretical yield to calculate percent yield for reactions performed in the lab.
6. Limiting reactants cause certain effects on chemical reactions.

Adapted from Ohio Revised Science Standards and Model Curriculum

Resources

* <http://education.ohio.gov/getattachment/Topics/Ohio-s-New-Learning-Standards/Science/HSscience_Model_Curriculum_April2014-1.pdf.aspx>

Skills

**Bloom's Taxonomy/DOK**

**Remember (Level 1)**

1. Describe how chemists use balanced chemical equations.
2. Explain how mole ratios are used in chemical calculations.

**Understand (Level 1 and 2)**

1. Balance chemical equations.
2. Explain the general procedure for solving a stoichiometric problem.
3. Use coefficients of the balanced chemical equations in stoichiometric calculations.
4. Convert number of moles of a substance to mass, volume of gas, volume of solution, and/or number of particles.
5. Calculate the concentration of a solution (molarity).

**Analyze (Level 3)**

1. Calculate the percent by mass of an element in a compound.
2. Distinguish between empirical and molecular formula.
3. Use dimensional analysis.
4. Perform stoichiometric calculations.
5. Explain how the amount of product in a reaction is affected by an insufficient quantity of any of the reactants.

**Evaluate (Level 3 and Level 4)**

1. Explain what the percent yield of a reaction measures.
2. Perform chemical reactions in the lab.
3. Calculate theoretical yield and percent yield for chemical reactions performed in the lab.
4. Determine the limiting reactant of a chemical reaction.

**Create (Level 4)**

1. Design a lab procedure to produce a certain amount of product.
2. Design a lab procedure to calculate the theoretical yield for a reaction.

Essential Questions

1. What properties are used to describe the nature of solutions?
2. In what ways can we quantify the concentration of a solution?
3. Why is the mole an important measurement in chemistry?
4. How can the molecular formula of a compound be determined experimentally?
5. How can tiny particles like atoms be counted?
6. How are balanced chemical equations used in stoichiometric calculations?
7. How can we calculate amounts of reactants and products in a chemical reaction?
8. How is the amount of product in a reaction affected by an insufficient quantity of any of the reactants?
9. What does the percent yield of a reaction measure and why is this important information about a reaction?

Stage 2: Assessment Evidence

The Stoichiometry of Chocolate Chip Cookies

Formative: Cooperative Group Work

Students practice dimensional analysis with familiar kitchen chemistry topics. This exercise gives students a familiar framework to which they can refer later when working with stoichiometry problems later in the unit.

Reaction Stoichiometry

Formative: Lab Assignment

This Guided Inquiry lab is from Investigating Chemistry through Inquiry. Link is in lab manual; scroll down to table of contents to locate it.

Chalk Lab

Summative: Lab Assignment

Students develop their own procedure to create precisely 5 g of chalk (CaCO3) from CaCl2 and Na2CO3.

POGIL Activities

Formative: Cooperative Group Work

Mole RatiosLimiting and Excess Reactants

Laboratory Work

Formative: Lab Assignment

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Lab Report

Summative: Writing Assignment

Following a laboratory investigation, the student analyzes the data collected, applies concepts to real life situations, and synthesizes information from the lab, class discussions, and additional research into a formal lab report. RERUN Recall what you did in lab. Explain how your hypothesis was supported or not supported by your data. Results: Organize data in a logical and appropriate manner such as chart, graph, etc. Unexpected results: Explain all errors and/or unexpected results. New things learned must be articulated clearly and completely.

Graphic Organizer

Formative: Graphic Organizer

Students make connections between concepts with the use of a graphic organizer.

Homework Problems

Formative: Homework

Students solve problems involving stoichiometry.

Quizzes

Formative: Quiz

Quizzes are used to gauge the progress of student understanding of learning content and skills.

White Board Races

Formative: Cooperative Group Work

Students work in pairs to answer questions presented to the class. Student pairs must show all work on individual white boards which they hold up for immediate feedback. More whiteboarding strategies are described in the link.

Unit Test

Summative: Test

Unit Test

Resources

Stage 3: Learning Plan

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2. Cooperative Learning Groups
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7. Critical Thinking

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* <https://pogil.org/about>

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2. Smart phone
3. Chromebooks, computers Internet
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Resources

* <http://phet.colorado.edu/en/simulations/category/chemistry>

Grades 9-12 Science  
Chemistry

Nuclear Reactions

Stage 1: Desired Results

Catholic Standards

DOC All Grades DOC: Catholic Standards

The Profession of Faith

Students will be able to

1. Recognize God in the world's order, beauty, and goodness (CCC 32).

Life in Christ

Students will be able to

2. Know that we must assume responsibility for the acts we perform (CCC 1781).

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Targeted Standards

NGSS Grade 9-12 NGSS: Science and Engineering Practices

Practice 8. Obtaining, evaluating, and communicating information

Obtaining, evaluating, and communicating information in 912 builds on K8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order 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 usefulness of each source.

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Practice 6. Constructing explanations (for science) and designing solutions (for engineering)

Constructing explanations and designing solutions in 912 builds on K8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.

Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Practice 7. Engaging in argument from evidence

Engaging in argument from evidence in 912 builds on K8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.

Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.

Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Practice 1. Asking questions (for science) and defining problems (for engineering)

Asking questions and defining problems in 912 builds on K8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.

Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.

Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.

Ask questions to clarify and refine a model, an explanation, or an engineering problem.

Evaluate a question to determine if it is testable and relevant.

Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.

Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.

Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and/or environmental considerations.

Practice 2. Developing and using models

Modeling in 912 builds on K8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria.

Design a test of a model to ascertain its reliability.

Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.

Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Practice 3. Planning and carrying out investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigations design to ensure variables are controlled.

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.

Select appropriate tools to collect, record, analyze, and evaluate data.

Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.

Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

Practice 4. Analyzing and interpreting data

Analyzing data in 912 builds on K8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.

Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.

Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.

Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.

Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Practice 5. Using mathematics and computational thinking

Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Apply techniques of algebra and functions to represent and solve scientific and engineering problems.

Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model makes sense by comparing the outcomes with what is known about the real world.

Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).

OH Grade 9-12 OH: Science (2011)

HS Chemistry

Science Inquiry and Application During the years of grades 9 through 12 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

Identify questions and concepts that guide scientific investigations;

Formulate and revise explanations and models using logic and evidence (critical thinking);

Recognize and analyze explanations and models

Communicate and defend a scientific argument.

Course Content: Interactions of Matter

Nuclear Reactions: Radioisotopes

Nuclear Reactions: Nuclear energy

OH Grades 11-12 OH: Literacy in History/Social Studies, Science, & Technical Subjects 6-12

Writing

Text Types and Purposes 1. Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence.

WHST.11-12.1. Write arguments focused on discipline-specific content.

WHST.11-12.1a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.

WHST.11-12.1b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audiences knowledge level, concerns, values, and possible biases.

WHST.11-12.1c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.

WHST.11-12.1d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

WHST.11-12.1e. Provide a concluding statement or section that follows from or supports the argument presented.

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

WHST.11-12.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

WHST.11-12.2a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.

WHST.11-12.2b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audiences knowledge of the topic.

WHST.11-12.2c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.

WHST.11-12.2d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.

WHST.11-12.2e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).

Production and Distribution of Writing 4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

WHST.11-12.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.

WHST.11-12.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

WHST.11-12.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

Research to Build and Present Knowledge 7. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

WHST.11-12.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.

WHST.11-12.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

Draw evidence from literary or informational texts to support analysis, reflection, and research.

WHST.11-12.9. Draw evidence from informational texts to support analysis, reflection, and research.

Range of Writing 10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

WHST.11-12.10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Reading: Science & Technical Subjects

Key Ideas and Details 1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

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.

Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.

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.

Analyze how and why individuals, events, or ideas develop and interact over the course of a text.

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 4. Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

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 1112 texts and topics.

Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole.

RST.11-12.5. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.

Assess how point of view or purpose shapes the content and style of a text.

RST.11-12.6. Analyze the authors 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 7. Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.

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.

Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.

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.

Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

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.

Read and comprehend complex literary and informational texts independently and proficiently.

RST.11-12.10. By the end of grade 12, read and comprehend science/technical texts in the grades 1112 text complexity band independently and proficiently.

Capacities of the Literate Individual

Students Who are College and Career Ready in Reading, Writing, Speaking, Listening, & Language

They demonstrate independence.

Catholic Identity

DOC All Grades Catholic Identity

Catholic Social Justice Teachings

Life and Dignity of the Human Person

Rights and Responsibilities

The Dignity of Work and the Rights of Workers

Call to Family, Community, and Participation

Option for the Poor and Vulnerable

Solidarity

Care for God's Creation

The Rights of Children

1. THE RIGHT TO A CATHOLIC COMMUNITY that witnesses to Christ and the Gospel by protecting them from child abuse, including sexual abuse and neglect.

2. THE RIGHT TO A SAFE ENVIRONMENT that promotes care, protection, and security.

3. THE RIGHT TO BE RESPECTED AS INDIVIDUALS with human dignity.

4. THE RIGHT TO WORK ACTIVELY TOWARD THEIR OWN EMPOWERMENT through the development of their gifts and talents.

5. THE RIGHT TO A LEARNING ENVIRONMENT THAT VALUES COOPERATION and challenges its members to critical and reflective thinking in their search for truth.

6. THE RIGHT TO DEVELOP POSITIVE, RESPONSIBLE AND CARING ATTITUDES AND BEHAVIORS TOWARD OTHERS and to recognize the rights of others to be safe and free from harassment and abuse.

7. THE RIGHT TO LEARN THE SKILL OF SELF PROTECTION by identifying safe and unsafe situations.

8. THE RIGHT TO LEARN RESPONSIBILITY for themselves and their actions.

9. THE RIGHT TO MAKE RESPONSIBLE DECISIONS founded on religious conviction.

10. THE RIGHT TO GUIDANCE FROM THE CHURCH in their development as loving people.

Summary

In this unit students will explore nuclear chemistry. Students will study nuclear reactions as a source of energy and write nuclear reaction equations for specific types of radioactive decay. Students compare and contrast the types of radiation including alpha, beta, gamma, and positron radiation. Students predict the products of and balance equations for nuclear reactions. Students will also study the advantages and disadvantages of applications of nuclear chemistry in society.

Unit Goals

1. Students will understand the differences between chemical reactions and nuclear reactions.
2. Students will understand that in nuclear reactions, small amounts of matter are converted into energy.
3. Students will understand that different types of nuclear radiation have different properties and interact differently with other matter.
4. Students will understand that there are advantages and disadvantages to using nuclear chemistry.

Big Ideas

1. Atomic structure dictates the properties and interactions of matter.
2. The sum total of matter and energy is conserved in nuclear reactions.

Enduring Understandings

1. There are many forms of nuclear radiation.
2. There are many forms of naturally occurring radiation to which people are exposed every day.
3. Danger from nuclear radiation depends on type of radiation and exposure.
4. Nuclear chemistry has many beneficial applications: medical diagnosis, medical treatment, chemical analysis, scientific tracers, production of electrical power, etc.
5. Nuclear chemistry also has many drawbacks: illness caused by overexposure, environmental damage from accidents, explosions, and waste, etc.

Content

**Nuclear Reactions**

**Radioisotopes**

1. Nuclear reactions are a source of energy.
2. Radioactive decay can result in various types of radiation.

alpha

beta

gamma

positron

1. Properties of alpha, beta, gamma, and positron radiation include:

mass

charge

potential to ionize and penetrate other matter

1. Beta decay results from the decay of a neutron.
2. Positron decay results from the decay of a proton.
3. When a radioisotope undergoes alpha, beta, or positron decay, the resulting nucleus can be predicted and the balanced nuclear equation can be written.

**Nuclear energy**

1. Nuclear fission and nuclear fusion reactions are accompanied by larger energy changes than chemical reactions.
2. It is theoretically possible to use nuclear reactions as a controlled source of energy.
3. Advantages of generating electricity from nuclear fission and fusion exist.
4. Disadvantages of generating electricity from nuclear fission and fusion exist.

Adapted from Ohio Revised Science Standards and Model Curriculum

Skills

**Bloom's Taxonomy/DOK**

**Remember (Level 1)**

1. Describe types of nuclear radiation.
2. Describe what happens in a nuclear chain reaction.

**Understand (Level 1 and 2)**

1. Compare the properties of types of radiation.
2. Explain the relationship between unstable isotopes and radioactivity.
3. Describe some practical uses of radioisotopes.

**Analyze (Level 3)**

1. Determine the factors that affect the type of decay a radioisotope undergoes.
2. Write and balance nuclear equations.
3. Solve problems that involve half-life.
4. Distinguish fission reactions from fusion reactions.

**Evaluate (Level 3 and Level 4)**

1. Predict the resulting nucleus of radioisotope decay.
2. Investigate the effects of nuclear radiation in various situations.

**Create (Level 4)**

1. Defend the use of nuclear chemistry in a particular circumstance.

Essential Questions

1. How does nuclear chemistry impact modern society?
2. What does stability mean in chemistry? What does it mean to say that a nucleus is unstable?
3. What happens when an unstable nucleus decays?
4. How is the structure of atoms altered during fission and fusion?
5. How does nuclear chemistry affect your life?

Stage 2: Assessment Evidence

Nuclear Radiation

Formative: Lab Assignment

This Guided Inquiry lab is from Investigating Chemistry through Inquiry. The link is the entire lab manual; scroll down to the table of contents for information on this particular lab.

Nuclear Chemistry in Society

Summative: Project

Students research the applications of nuclear chemistry in society, develop a position, use evidence to justify their position, and present their work to the class.

POGIL Activities

Formative: Cooperative Group Work

In cooperative groups, students will complete the Nuclear Chemistry: What is Radiation? activity.

Laboratory Work

Formative: Lab Assignment

Teachers can assign labs from the laboratory manual, create their own labs, or use labs from web sources, many of which are listed in the reference section. Laboratory exercises are a necessary part of high school science; however, not all schools have the same equipment, so any variety of labs may be used to aid students in their understanding of unit concepts. They can be formative, exploring a new concept, or summative, showing a practical application of concept knowledge.

Lab Report

Summative: Writing Assignment

Following a laboratory investigation, the student analyzes the data collected, applies concepts to real life situations, and synthesizes information from the lab, class discussions, and additional research into a formal lab report. RERUN Recall what you did in lab. Explain how your hypothesis was supported or not supported by your data. Results: Organize data in a logical and appropriate manner such as chart, graph, etc. Unexpected results: Explain all errors and/or unexpected results. New things learned must be articulated clearly and completely.

Graphic Organizer

Formative: Graphic Organizer

Students make connections between concepts using graphic organizers.

Homework Problems

Formative: Homework

Students solve problems involving nuclear chemistry.

Quizzes

Formative: Quiz

Quizzes are used to gauge the progress of student understanding of learning content and skills.

White Board Races

Formative: Cooperative Group Work

Students work in pairs to answer questions presented to the class. Student pairs must show all work on individual white boards which they hold up for immediate feedback. More whiteboarding strategies are described in the link.

Unit Test

Summative: Test

Unit Test

Stage 3: Learning Plan

Learning Experiences

1. Guided Inquiry
2. Cooperative Learning Groups
3. POGIL Activities
4. Graphic Organizers
5. Small Group and Class Discussions
6. Direct Instruction
7. Critical Thinking

Resources

* <https://pogil.org/about>

Technology Integration

1. Smart Board
2. Smart phone
3. Chromebooks, computers Internet
4. Graphing software (Excel, LoggerPro)
5. Vernier software and hardware
6. Pasco software and hardware
7. iPad apps
8. Phet simulations
9. LCD projector
10. PowerPoint
11. Internet resources
12. Online video clips

Resources

**Books**

1. Trout, L. (2012). *POGIL activities for high school chemistry*. Batavia, IL: Flinn Scientific, Inc.
2. Wilbraham, A., et al. (2012). *Chemistry.* New York: Pearson.
3. Timberlake, K., and Timberlake, W. (2008). *Basic chemistry*, 2nd edition. New York: Prentice Hall.
4. Buthelezi,T., Dingrando, L., Hainen, N. (2008). *Chemistry: Matter and change. New York:* Glencoe, 2008.
5. Volz, D.L., and Smola, R. (2009). *Investigating chemistry through inquiry*. Beaverton, OR: Vernier.
6. Holmquist, D.D., Randall, J., and Volz, D.L. (2007). *Chemistry with Vernier.* Beaverton, OR: Vernier.

Resources

* <http://modelinginstruction.org/>