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## UNIT NARRATIVE

### UNIT NARRATIVE

**Unit Phenomenon Anchoring Event: Blood Diamond Identification** Atoms of the same element are not always exactly the same and therefore can have observable differences between samples. *How can we differentiate where a diamond was mined, since all diamonds are made up of the pure element carbon. If an element is a pure substance, how is it possible to distinguish one pure element for another?*

Unit 01 serves as an in-depth investigation into the structure of individual atoms and the methods scientists use to analyze and quantify atoms of an element. Through this study, students explore the identity and arrangement of subatomic particles and discover how patterns in atomic structure explain properties and behaviors of matter. They also develop the mathematical tools needed to connect the particulate scale of atoms to measurable macroscopic quantities, laying the foundation for future work with chemical reactions and stoichiometry.

The anchoring phenomenon (*How can we trace a diamond back to its source?*) guides this inquiry. To answer this question, students must investigate protons, electrons, and neutrons in turn, analyzing evidence to rule out potential explanations before arriving at the distinguishing characteristic of carbon samples. This structured progression prevents premature resolution of the phenomenon, sustains curiosity, and reinforces that science is built on evidence-based elimination and reasoning.

The unit moves through a four-part progression: atomic structure and periodic table foundations, electron organization and behavior, neutrons and isotopes, and the mole concept and quantitative analysis. This organization ensures each concept builds on prior knowledge while advancing toward the unit's explanatory goal.

1. **Atomic Structure and Periodic Table Foundations:** The unit opens with an anchoring event centered on conflict diamonds, providing a meaningful context for inquiry. Students learn what makes a scientific question answerable and construct initial hypotheses as starting points for investigation. They understand that hypotheses will evolve as new evidence emerges, establishing the iterative nature of science. Students review the atomic theory of matter, reinforcing the identity-defining role of protons and the meaning of atomic number. They analyze how the sequence and shape of the periodic table reflect increasing atomic number, which also means increasing number of protons. Through this work, students eliminate protons as a distinguishing factor between carbon atoms, recognizing that changing proton count changes the element itself.

2. **Electron Organization and Behavior:** Building on periodic patterns, students explore how electrons occupy shells and subshells, beginning with full configurations and transitioning to noble gas notation to highlight core and valence electrons. Lewis dot structures visually represent valence electrons and prepare students for bonding concepts later in the course. Next, students investigate energy behavior in electrons, beginning with the Rubber Band Lab to model energy storage and release. Flame test experiments follow, where students collect and analyze data on photon emission and calculate energy relationships. These investigations reveal that electrons can absorb and release energy without altering the atom's identity and effectively eliminating electrons as the source of observable differences between carbon atoms.
3. **Neutrons and Isotopes:** With protons and electrons ruled out, students turn to neutrons, discovering that isotopic variation provides the key to distinguishing between atoms of the same element. They learn how differences in neutron number produce measurable differences in mass and interpret mass spectrometry data to identify isotopic composition. Mass spectrum graphs allow students to determine relative abundances and calculate average atomic mass, providing the evidence needed to trace diamond samples to their geographic origin.
4. **Mole Concept and Quantitative Analysis:** The unit concludes by bridging the microscopic world of atoms to measurable macroscopic quantities through the mole concept. Students learn why the mole concept is necessary to analyze atomic samples and develop fluency in dimensional analysis. They first perform one-step conversions between mass and moles using molar mass, which was determined using the universal average atomic mass from the previous lessons. Next they convert between moles and particles, which culminates into combining these skills for two-step conversions that link all three quantities. These problem-solving routines are reinforced through unit cancellation and sense-checking strategies, laying the foundation for stoichiometric reasoning in later units.

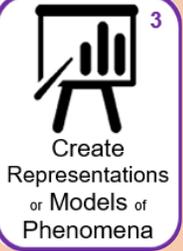
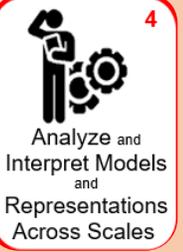
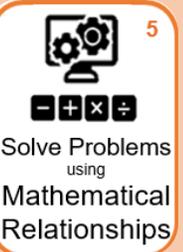
**Do not skip the seamless explanation throughout the unit. It builds writing and argumentation skills essential for developing disciplinary literacy in science.**

## CONTENT STANDARDS

Below are the standards **taught** and **assessed** in this unit.

FIRST INSTRUCTION STANDARDS	
Learning Objectives	Essential Knowledge
<p><b>2.1.A.1</b> Distinguish between atoms, <del>molecules, and compounds</del> at the particle level. <i>Note: Categorizing atoms by subatomic particle distribution.</i></p> <p><b>2.1.A.2</b> Create and/or evaluate models of pure substances. <i>Note: Categorizing atoms and analyzing mixtures of isotopes using subatomic particle distribution lens.</i></p>	<p><b>2.1.A</b> A pure substance always has the same composition. Pure substances include elements, molecules, and compounds.</p> <ol style="list-style-type: none"> <li>a. An element is composed of only one type of atom.</li> <li>b. <del>A molecule is a particle composed of more than one atom.</del></li> <li>c. <del>A compound is composed of two or more elements and has properties distinct from those of its component atoms.</del></li> </ol>
<p><b>2.1.B.1</b> Create and/or evaluate models of mixtures.</p> <p><b>2.1.B.2</b> Interpret the results of an experiment involving the separation of a mixture. <i>Note: Separating isotopes and mass spectrometry lens.</i></p>	<p><b>2.1.B</b> A mixture is composed of two or more different types of particles that are not bonded.</p> <ol style="list-style-type: none"> <li>a. Each component of a mixture retains its unique properties.</li> <li>b. <del>Mixtures can be separated using physical processes such as filtration, evaporation, distillation, and chromatography.</del></li> </ol>

<p><b>2.2.C.1</b> Describe trends in properties of elements based on their position in the periodic table and the <b>shell model</b> of the atom. <i>Note: Shell model of the atom and electron behavior lens.</i></p>	<p><b>2.2.C</b> The periodic table is an organizational tool for elements based on their properties.</p> <ol style="list-style-type: none"> <li>Patterns of behavior of elements are based on the <b>number of electrons in the outermost shell (valence electrons)</b>.</li> <li>Important periodic trends include electronegativity and atomic radius</li> </ol>				
<p><b>2.2.D.1</b> Create and/or evaluate <b>Lewis diagrams</b> for molecular compounds and/or polyatomic ions. <i>Note: Lewis dots of neutral elements only.</i></p>	<p><b>2.2.D</b> A Lewis diagram is a <b>simplified representation</b> of a molecule.</p> <ol style="list-style-type: none"> <li>Lewis diagrams show the bonding patterns between <b>atoms</b> in a molecule.</li> </ol>				
<p><b>2.3.C.1</b> Explain the relationship between the relative strength of attractions between cations and anions in an ionic solid in terms of the charges of the ions and the distance between them. <i>Note: Introduction to Coulomb's Law and attraction between protons in nucleus and electrons in shells as a means of storing energy in the atom as potential energy lens.</i></p>	<p><b>2.3.C</b> Ionic solids are made of <b>cations</b> and <b>anions</b>:</p> <ol style="list-style-type: none"> <li>The relative number of cations and anions retain overall electrical neutrality.</li> <li>As the charge on each ion increases the relative strength of the interaction will also increase.</li> <li>As the distance between ions increases the relative strength of the interaction will decrease.</li> </ol>				
<p><b>3.1.A.1</b> Explain the relationship between the mass of a substance, the number of particles of that substance, and the number of moles of that substance. <i>Note: Pure elements only.</i></p> <p><b>3.1.A.2</b> Use the mole concept to calculate the mass, number of particles, or number of moles of a given substance. <i>Note: Pure elements only.</i></p>	<p><b>3.1.A</b> A large number of particles of a substance is needed to measure the physical properties of that substance.</p> <ol style="list-style-type: none"> <li>A mole of a substance contains Avogadro's number (<math>6.02 \times 10^{23}</math>) of particles.</li> <li>The molar mass of an element listed on the periodic table is the mass, in grams, of a mole of atoms of that element.</li> </ol>				
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<b>DISCIPLINARY LITERACY</b>					
<b>Science Practices</b>	<b>Skills</b>				
<div style="display: flex; align-items: center;">  <div style="margin-left: 10px;"> <p><b>Science Practice 1: Models and Representations</b></p> <p>Describe models and representations, including across scales.</p> </div> </div>	<p><b>1.A</b> Describe the components of and quantitative information from models and representations that illustrate particulate-level properties only.</p> <p><b>1.B</b> Describe the components of and quantitative information from models and representations that illustrate both particulate-level and macroscopic-level properties.</p>				

 <p><b>2</b> Determine Scientific Questions and Methods</p>	<p><b>Science Practice 2: Question and Method</b> Determine scientific questions and methods.</p> <p><b>2.A</b> Identify a testable scientific question based on an observation, data, or a model.  <b>2.B</b> Formulate a hypothesis or predict the results of an experiment.  <b>2.C</b> Identify experimental procedures that are aligned to a scientific question (which may include a sketch of a lab setup).  <b>2.D</b> Make observations or collect data from representations of laboratory setups or results, while attending to precision where appropriate.  <b>2.E</b> Identify or describe potential sources of experimental error.  <b>2.F</b> Explain how modifications to an experimental procedure will alter results.</p>
 <p><b>3</b> Create Representations or Models of Phenomena</p>	<p><b>Science Practice 3: Representing Data and Phenomena</b> Create representations or models of chemical phenomena.</p> <p><b>3.A</b> Represent chemical phenomena using appropriate graphing techniques, including correct scale and units.  <b>3.B</b> Represent chemical substances or phenomena with appropriate diagrams or models (e.g., electron configuration).  <b>3.C</b> Represent visually the relationship between the structures and interactions across multiple levels or scales (e.g., particulate to macroscopic).</p>
 <p><b>4</b> Analyze and Interpret Models and Representations Across Scales</p>	<p><b>Science Practice 4: Model Analysis</b> Analyze and interpret models and representations on a single scale or across multiple scales.</p> <p><b>4.A</b> Explain chemical properties or phenomena (e.g., of atoms or molecules) using given chemical theories, models, and representations.  <b>4.B</b> Explain whether a model is consistent with chemical theories.  <b>4.C</b> Explain the connection between particulate-level and macroscopic properties of a substance using models and representations.  <b>4.D</b> Explain the degree to which a model or representation describes the connection between particulate-level properties and macroscopic properties.</p>
 <p><b>5</b> Solve Problems using Mathematical Relationships</p>	<p><b>Science Practice 5: Mathematical Routines</b> Solve problems using mathematical relationships.</p> <p><b>5.A</b> Identify quantities needed to solve a problem from given information (e.g., text, mathematical expressions, graphs, or tables).  <b>5.B</b> Identify an appropriate theory, definition, or mathematical relationship to solve a problem.  <b>5.C</b> Explain the relationship between variables within an equation when one variable changes.  <b>5.D</b> Identify information presented graphically to solve a problem.  <b>5.E</b> Determine a balanced chemical equation for a given chemical phenomenon.  <b>5.F</b> Calculate, estimate, or predict an unknown quantity from known quantities by selecting and following a logical computational pathway and attending to precision (e.g., performing dimensional analysis and attending to significant figures).</p>



**Science Practice 6:  
Argumentation**  
Develop an  
explanation or  
scientific argument.

- 6.A** Make a scientific claim.
- 6.B** Support a claim with evidence from experimental data.
- 6.C** Support a claim with evidence from representations or models at the particulate level, such as the structure of atoms and/or molecules.
- 6.D** Provide reasoning to justify a claim using chemical principles or laws or using mathematical justification.
- 6.E** Provide reasoning to justify a claim using connections between particulate and macroscopic scales or levels.
- 6.F** Explain the connection between experimental results and chemical concepts, processes, or theories.
- 6.G** Explain how potential sources of experimental error may affect the experimental results.

### PACING GUIDE

Use this section to plan when each day of instruction will occur. Use the suggested timing table above to guide your pacing in the table below.

UNIT AT A GLANCE			
Lesson #	Lesson Date	Topic	Pacing Notes
01		Anchoring Event Introduction: Blood Diamonds	
02		Periodic Table Introduction: Sequence and Shape (Atomic Number and Electron Organization)	
03		Full Electron Configuration Only	
04		Noble Gas Notation (Core/Valence), Valence Shell and Lewis Dots	
05		Electron Excitation and Potential Energy Rubber Band Lab	
06		Flame Test Day 1: Data Collection	
07		Flame Test Day 2: Data Analysis and Light Calculations	
08		Isotope Investigation	
09		Introduction to Mass Spectrometry	
10		Mass Spectrum Graphs: Finding Average Atomic Mass / Molar Mass	

11		Mole Concept: Counting Atoms One Step Dimensional Analysis with Molar Mass: Mass $\leftrightarrow$ Moles	
12		One Step Dimensional Analysis: Moles $\leftrightarrow$ Particles	
13		Two Step Dimensional Analysis: Mass $\leftrightarrow$ Moles $\leftrightarrow$ Particles	
REV		Unit 01 Exam Review	
UE		Unit 01 Exam	
FLEX/ER		(Varies by Region)	

## UNDERSTANDINGS AND QUESTIONS

Important big ideas and processes for the unit.

KEY UNDERSTANDINGS	TEACHER NOTES
<ul style="list-style-type: none"> <li><input type="checkbox"/> Phenomena are events or processes (“things that happen”) that are observable by senses or detectable by instruments.</li> <li><input type="checkbox"/> An answerable scientific question cannot be answered with a yes/no response, is specific and focused, and is based on observable phenomena or patterns</li> <li><input type="checkbox"/> An answerable scientific question cannot be answered with a yes/no response, is specific and focused, and is based on observable phenomena or patterns.</li> <li><input type="checkbox"/> An initial hypothesis is a tentative explanation or prediction to an answerable scientific question based on prior knowledge and observations.</li> <li><input type="checkbox"/> The purpose of an initial hypothesis is to provide a starting point for scientific inquiry that will be revised, refined, or even rejected and rewritten over time as new data and insights are gathered during an investigation.</li> <li><input type="checkbox"/> Elements are substances composed of a single type of atom.</li> <li><input type="checkbox"/> The atomic number of an element is equal to the number of protons present in the nucleus of an atom and defines the element.</li> <li><input type="checkbox"/> Electrons have negligible mass, a single negative charge, and are constantly moving outside the nucleus within defined areas.</li> <li><input type="checkbox"/> The sequence of elements on the periodic table is determined by increasing atomic number (or increasing number of protons).</li> <li><input type="checkbox"/> The periodic table’s unique shape is due to the arrangement of electrons around the atom.</li> <li><input type="checkbox"/> Electrons are arranged into energy levels/shells surrounding the nucleus.</li> <li><input type="checkbox"/> Each energy level/shell holds a specific number of electrons.</li> <li><input type="checkbox"/> There are four types of subshells that hold unique number of electrons (s=2, p=6, d=10, f=14) and electrons fill subshells from lowest to highest energy.</li> <li><input type="checkbox"/> Each neutral element has a unique electron configuration that can be found using the periodic table and reading it from left to right, top to bottom until you reach the desired element.</li> </ul>	

- Electrons fill and are written from lowest to highest potential energy, not by distance from the nucleus.
- Special rules apply to numbering of d and f subshells using the periodic table due to them filling after the s valence subshell due to higher potential energy, but before the p valence subshell.
- Full electron configurations can be written in shorthand by using noble gases.
- Core electrons are all electrons of an electron configuration that are not in a valence shell.
- The valence shell is the outermost energy level/shell of an atom that contains electrons.
- Valence electrons are only found in s and p subshells.
- When a d or f subshell is filling with electrons, it is filling a lower energy level than the valence shell therefore a d or s subshell will NEVER be occupied by valence electrons.
- Valence shell electrons of an atom are represented using Lewis dot structures.
- When energy is applied to an atom, it can absorb that energy as potential energy based on electron position.
- Excitation is the process where an electron bound to an atom jumps into a higher energy shell or orbital of that same atom, existing in a higher energy state due to the absorption of energy.
- The amount of potential energy an electron holds increases as the quantum jump distance from the normal configuration position increases.
- The excited state electron configuration will have the same number of electrons as the ground state configuration, but one or more electrons will be displaced into a higher energy orbital than their ground state configuration.
- Photon emission occurs when an excited electron moves back to ground state to release the absorbed energy without altering the atom itself.
- Because energy cannot be created or destroyed, the emitted energy in the form of light is the same energy that was absorbed by the atom.
- The color of light emitted can be used to quantify the amount of energy absorbed and released using known relationships and equations.
- The color of light emitted can be used to estimate relative energy absorbed and released by different atoms, with red being lowest and purple being highest per the electromagnetic spectrum.
- Wavelength and frequency have an inversely proportional relationship; as wavelength increases, frequency decreases.
- High energy waves have a high frequency and short wavelength.
- Atoms are neutrally charged due to having an equal number of positive protons and negative electrons.
- Protons and neutrons have mass and are located in the nucleus.
- Atoms are mostly empty space with an extremely dense nucleus in the center.
- Isotopes are atoms of the same element that have the same number of protons but different masses due to having a different number of neutrons.
- Each nuclear symbol represents an individual isotope of an element.
- The mass number of an isotope is found by adding the number of protons to the number of neutron, each valued at 1 atomic mass unit (amu).
- A mass spectrometer sorts samples based on the mass of each particle and the charge of each particle.
- Since it is assumed all particles have the same charge, the amount of deflection is based on the mass of the particle with larger particles deflecting less and lighter particles deflecting more.
- Abundance values for isotopes of the same element communicate the proportion of that isotope present within a sample.

- Mass spectrum graphs communicate the number of isotopes, the relative abundance of isotopes, and the mass of the isotopes present in a sample.
- The average atomic mass of an element is the weighted average of all atomic masses (or mass numbers) using the natural abundance of isotopes on earth.
- The distribution of isotopes in a single sample can differ between individual sources.
- Moles are used to count groups of atoms, since atoms are so incredibly small and impossible to count or measure individually.
- Mass is an experimentally more useful unit of measurement for macroscopic samples than moles because it can be efficiently and accurately measured.
- The periodic table communicates the element symbol, the atomic number, the electron configuration, and the molar mass of each element.
- Molar mass is the mass of one mole of particles of that substance expressed in grams per mole, or g/mol.
- Dimensional analysis is a mathematical routine that allows us to analyze or quantify the same sample or amount of a substance with different units (or dimensions) by using known conversion factors in fraction form.
- Dimensional analysis is used to convert between the mass of a substance and the moles of a substance using molar mass.
- Unit cancelling should be used to check work every time you complete dimensional analysis.
- Avogadro's Number is the number of particles in one mole of a sample of a substance and is equal to  $6.02 \times 10^{23}$ .
- There is no direct conversion between the mass that can be measured in a laboratory and the number of particles present in that sample, so this will require a two-step conversion that first converts to moles.
- A seamless explanation for an unknown physical phenomenon integrates evidence from the unit of study, uses scientific concepts in the checklist provided, is comprehensive and includes both inclusionary and exclusionary reasoning for each piece of evidence, reflects understanding and critical thinking, and is clear and logical with no gaps in evidence or reasoning.

### KEY QUESTIONS

- How do I develop an answerable question for an observable, physical phenomena?
- How do I write an initial hypothesis for observable, physical phenomena?
- What is the intention and purpose of an initial hypothesis?
- How is the sequence of elements on the periodic table determined?
- How is the shape of the periodic table determined?
- How are electrons distributed around the atom?
- How do I create the full electron configuration of an element?
- How do I abbreviate the electron configuration of larger elements?
- What is the difference between core and valence electrons?
- What is the purpose of a Lewis dot structure for atoms and how do I create one?
- How is energy stored in the atom?
- How does an atom release stored energy?
- Why is colored light emitted from atoms when introduced to an energy source?
- What is the relationship between wavelength, frequency, and energy?
- How do I calculate the estimated energy of a photon from its color?

### TEACHER NOTES

- What are the implications of changing the number of each subatomic particle of an atom of a specific element?
- How does a mass spectrometer separate a mixture of isotopes?
- How do I analyze and interpret a mass spectrum graph?
- How is the average atomic mass obtained for an element for the periodic table?
- What is the purpose of a mole in chemistry?
- Why is knowing the molar mass of a substance useful?
- How is molar mass used in chemistry in quantitative analysis?
- How is Avogadro's number used in chemistry in quantitative analysis?
- How can dimensional analysis be used to evaluate quantities of atoms of a single element?
- How is a seamless explanation that fully answers the essential question of study for the unit created for a physical phenomenon?

## VERTICAL STANDARDS

This section details the **progression** of key scholar expectations/standards\*\* in the courses **before** and **after** this course. This will help you understand what **prior knowledge skills to build upon** and guide you in knowing what **skills you are preparing your scholars** for in the subsequent course.

### NGSS Science Practices

#### NGSS Science Practices

- 1. Asking Questions** Scientific questions lead to explanations of how the natural world works and can be empirically tested using evidence.
  - ❖ Students generate hypotheses and essential questions about atomic differences in the Conflict Diamonds anchoring phenomenon (Lessons 01–02), aligned with asking testable questions to refine models of natural systems.
- 2. Developing and Using Models** A model is an abstract representation of phenomena that is a tool used to predict or explain the world. Models can be represented as diagrams, 3-D objects, mathematical representations, analogies or computer simulations.
  - ❖ Students build and revise atomic models using subatomic particles, electron configurations, and shell structures (Lessons 02–06), mirroring how Biology students model organelles, cells, and energy flow.
  - ❖ Electron movement and energy diagrams (Lessons 05–07) provide practice evaluating model limitations and representations.
- 3. Planning and Carrying Out Investigations** An investigation is a systematic way to gather data about the natural world either in the field or in a lab setting.
  - ❖ Students conduct a flame test lab (Lessons 06–07) and analyze emission results, mirroring the procedural thinking needed for Biology labs like enzyme function or diffusion.
- 4. Analyzing and Interpreting Data** Analyzing and interpreting data includes making sense of the data produced during investigations. Because patterns are not always obvious, this includes using a range of tools such as tables, graphs and other visualization techniques.
  - ❖ Interpretation of mass spectra, spectral lines, and graphical data (Lessons 06, 09) aligns with how Biology students use graphs and tables to analyze macromolecule composition, respiration rates, or photosynthetic activity.
- 5. Using Mathematics and Computational Thinking** Mathematical and computational thinking involves using tools and mathematical concepts to address a scientific question.
  - ❖ Dimensional analysis and use of equations like  $E = hv$  and  $pH = -\log[H^+]$  (Lessons 07, 11–13) reinforce quantitative reasoning used in biological contexts like calculating respiration yield or solute concentrations.
- 6. Constructing Explanations** A scientific explanation is an explanatory account that articulates how or why a natural phenomenon occurs that is supported by evidence and scientific ideas.

❖ Students construct CER explanations and Seamless Explanation models of atomic behavior and traceability of diamonds (Lessons 01, 10, 13–14), building habits that transfer to explaining biological processes like homeostasis or protein synthesis.

**7. Engaging in Argument from Evidence** Scientific argumentation is a process that occurs when there are multiple ideas or claims (e.g. explanations, models) to discuss and reconcile. An argument includes a claim supported by evidence and reasoning, and students engage in debates to evaluate and critique competing arguments.

❖ During the flame test and mass spectra lessons (Lessons 06–10), students evaluate competing claims about atomic identity using empirical evidence, reinforcing skills used to compare biological hypotheses (e.g., genetic expression models).

**8. Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating and communicating information occurs through reading and writing texts as well as communicating orally. Scientific information needs to be critically evaluated and persuasively communicated as it supports the engagement in the other science practices.

❖ Throughout Unit 01, students read graphs and spectra, discuss evidence with peers, and communicate explanations in visual, verbal, and written formats, directly supporting the communication demands of Biology labs and argumentation tasks.

## 6<sup>th</sup> - 8<sup>th</sup> TEKS

### **Matter and Energy TEKS Introduction Vertical Alignment**

**Grade 6:** Students build upon their knowledge of properties of solids, liquids, and gases and further explore their molecular energies. In Grade 6, students learn how elements are classified as metals, nonmetals, or metalloids based on their properties on the Periodic Table. Students have previous experience with mixtures in Grade 5. Grade 6 furthers their understanding by investigating the different types of mixtures. Subsequent grades will learn about compounds. In Grade 6, students compare the density of substances relative to fluids and identify evidence of chemical changes.

**Grade 7:** Students have prior experience with elements in Grade 6 and develop an understanding that compounds are also pure substances in Grade 7. Students investigate the differences between elements and compounds through observations, descriptions of physical properties, and chemical reactions. Students build upon their understanding of solutions by exploring aqueous solutions.

**Grade 8:** Students make connections between elements, compounds, and mixtures that were introduced in prior grade levels. Students examine the properties of water, acids, and bases. In addition, students understand the basic concept of conservation of mass using chemical equations.

### **TEKS Content Vertical Alignment**

Pre-AP Chemistry Unit 01 builds on the Grades 6–8 TEKS by deepening students' understanding of atomic structure, subatomic particles, matter classification, and energy transformations, all while embedding scientific practices such as modeling, data interpretation, and experimental reasoning. The unit reinforces middle school standards on how atoms determine identity and behavior of elements, how matter is organized and conserved, and how scientific knowledge is developed and refined through models and evidence. Students apply these foundational middle school concepts while engaging in increasingly rigorous scientific reasoning, preparing them for high school-level scientific literacy and quantitative analysis.

#### **6–8.1 Scientific and Engineering Practices**

❖ **6-8.1(A–B):** Students engage in experimental investigations including the flame test lab (Lesson 06) and mass spectrometry analysis (Lessons 09–10), using methods appropriate to the questions posed (comparative for flame color; descriptive and correlative for isotope data).

❖ **6-8.1(C–D):** Students use balances, periodic tables, pH indicators, and lab notebooks in practical applications aligned to TEA-approved safety protocols and tool use expectations in labs (Lessons 06 and 09).

#### **6–8.2 Nature of Science**

❖ Students analyze atomic data to generate testable claims about the origin and identity of samples (Lessons 01, 06, 09), consistent with the TEKS emphasis on using evidence to construct explanations and distinguishing testable from untestable phenomena.

### 6–8.3 Observations, Inferences, Hypotheses, and Theories

- ❖ **6-8.3(A–B):** Students record spectral data (observations), propose hypotheses about flame color identity or mass spectra (inferences), and revise hypotheses based on new evidence (Lessons 06, 10).
- ❖ **6-8.3(C–D):** Unit 01 scaffolds the distinction between a testable hypothesis (e.g., a compound emits red light because of strontium ions) and a robust theory (e.g., quantum theory of electron excitation).

### 6–8.4 Science and Social Ethics

- ❖ The Conflict Diamonds anchoring phenomenon (Lesson 01) prompts ethical considerations about scientific methods and social decisions in sourcing materials, promoting critical engagement with the TEKS expectation of distinguishing between ethical/scientific decision-making.

### 6–8.5 Recurring Themes and Concepts

- ❖ **6-8.5(A):** Students identify patterns in periodic properties, isotopic abundances, and spectral colors to build and revise models of atomic structure (Lessons 02–04, 09–10).
- ❖ **6-8.5(B):** Students analyze cause-and-effect relationships such as the link between electron energy levels and light emission in flame tests (Lessons 05–07).
- ❖ **6-8.5(C–D):** Scale and system modeling are emphasized in particle-level diagrams of atoms, isotopes, and mass spectra (Lessons 02–04, 09).
- ❖ **6-8.5(E):** Students trace energy transfer through absorption and emission using the conservation of energy to justify photon production (Lessons 05–07).
- ❖ **6-8.5(F–G):** Students evaluate how structure (electron configuration, nuclear composition) determines function (reactivity, mass, and light emission) and how atomic changes affect system stability (Lessons 03–05, 10).

### 6–8.6 Matter and Energy

- ❖ **8.5(A):** Students describe subatomic structure using atomic models and periodic tables, explicitly linking particle identity to structure and charge (Lessons 02–04).
- ❖ **8.5(B):** Students apply valence electron concepts to explain periodic trends and potential chemical behavior (Lesson 04).
- ❖ **7.6(A):** Students distinguish elements and compounds by analyzing isotope data and modeling pure substances in mass spectrometry and flame tests (Lessons 08–10).
- ❖ **8.6(A) and 6.6(B):** Students classify matter as elements or isotopes and identify types of mixtures by investigating diamond purity and traceability (Lessons 01, 08–09).
- ❖ **7.6(B) and 8.6(B):** Students use periodic tables to determine atomic makeup and interpret atomic models, including shorthand and full configurations (Lessons 03–04).

## PreAP Biology

### ECO 1.2.1 – Abiotic to Biotic Transport of Elements

Lessons 01–04 introduce atoms as the building blocks of matter and detail how carbon and other elements are arranged in atoms, providing chemistry context for how these elements cycle into macromolecules in ecosystems.

### CELLS 7.1.1 – Cellular Respiration and ATP Synthesis

Lessons 05–07 on electron excitation, energy levels, and photon emission prepare students to understand how electrons carry energy through cellular respiration, mirroring the function of NADH/FADH<sub>2</sub> in the mitochondrial electron transport chain.

## AP Biology

Pre-AP Chemistry Unit 01 builds foundational understanding of atomic structure, electron configuration, and the energy transformations that govern molecular behavior, concepts that are critical in AP Biology for explaining macromolecule composition, membrane function, and energy processes such as photosynthesis and cellular respiration. Students' early exposure to subatomic particles, electron behavior, Coulombic attractions, and energy diagrams in

Chemistry supports their later understanding of how biological molecules form and function, how membranes regulate molecular movement, and how electron transfer powers ATP production through chemiosmosis.

### **Topic 1.2 – Elements of Life**

Understanding atoms as building blocks and counting subatomic particles (Lessons 01–04) supports ENE–1.A.2 regarding how carbon, nitrogen, and phosphorus form macromolecules like carbohydrates, proteins, lipids, and nucleic acids.

### **Topic 2.2 – Cell Structure and Function**

Lessons 05–07, which describe electron excitation and transport, help build understanding of SYI–1.F.4, where chlorophyll pigments and ETC proteins use high-energy electrons to drive photosynthesis.

### **2.5 – Membrane Permeability**

Lessons 02–04 introduce charge, polarity, and electron distributions that connect directly to ENE–2.C.4, explaining why small nonpolar molecules (like O<sub>2</sub> and CO<sub>2</sub>) freely pass through membranes, while ions and polar molecules require transport proteins.

### **Topic 2.7 – Facilitated Diffusion**

Understanding electron charge and distribution (Lessons 02–04) and how charges affect energy (Lesson 05) prepares students for ENE–2.G.1, which explains how ions like Na<sup>+</sup> and K<sup>+</sup> require channels due to their charge.

### **Topic 2.9 – Mechanisms of Transport**

Particulate and symbolic modeling in Unit 01 supports the visualization of active and passive transport mechanisms, reinforcing ENE–2.J.1 across chemical gradients.

### **Topic 3.5 – Photosynthesis**

Lessons 05–07, which teach how electrons absorb and release energy via excitation and emission, directly support ENE–1.J.1–4 about how light energy excites electrons in photosystems and creates a proton gradient for ATP synthesis.

### **Topic 3.6 – Cellular Respiration**

Lessons 05–07 set up the concepts of electron carriers, charge separation, and proton gradients. These tie to ENE–1.K.3 and ENE–1.L.3–5, which describe how NADH and FADH<sub>2</sub> donate electrons to the ETC and drive ATP production through oxidative phosphorylation.

## **AP Environmental Science**

Pre-AP Chemistry Unit 01 develops the foundational quantitative reasoning skills essential for success in AP Environmental Science, especially in applying dimensional analysis, using unit-based reasoning, and calculating accurate values with appropriate units. Students practice selecting appropriate conversion factors, interpreting scientific notation, and justifying their approach to solving problems, skills that directly support APES Science Practice 6 across topics involving toxicity, energy flow, resource use, pollution, and conservation strategies.

### **Math Skills:**

- ❖ **Dimensional Analysis:** Using unit conversions to manipulate known quantities will always appear on the AP exam.
- ❖ **Density:** Must understand density qualitatively and calculate with density quantitatively.
- ❖ **pH:** Must know the basics of the pH scale, that each whole number on the pH scale is a factor of 10 change in hydrogen ion concentration.
- ❖ **Scientific Notation.** Will often use scientific notation in the givens of a problem and scholars must know how to understand what the number means and quantify larger or smaller numbers in scientific notation as well as multiply or divide with scientific notation using the calculator.
- ❖ **Percentages:** Must know how to add, subtract, multiply or divide using percentages without a calculator.
- ❖ **Percent Change:** Must know how to calculate percent change with the same mathematical routine chemistry uses for percent yield.

- ❖ **Metric Conversion:** Convert between metric prefixes using dimensional analysis.
- ❖ **Algebraic Equations:** Scholars must know how to identify givens and unknowns, rearrange algebraic equations to isolate a variable, and solve for the unknown value.

## AP CHEMISTRY

### Topic 1.1 – Moles and Molar Mass

1.1.A Calculate quantities of a substance or its relative number of particles using dimensional analysis and the mole concept.

*Pre-AP Unit 01 Alignment:*

- ❖ Lessons 11–13 build mastery of one- and two-step dimensional analysis using molar mass and Avogadro's number.
- ❖ Students explain why particles are counted using moles and interpret relationships among mass, moles, and particles.
- ❖ Unit 01 emphasizes clear unit labeling, identity tagging (e.g., "mol C"), and logical sequencing of conversion factors.
- ❖ These skills prepare students for complex stoichiometric reasoning in AP Chemistry.

### Topic 1.2 – Mass Spectroscopy of Elements

1.2.A: Explain the quantitative relationship between the mass spectrum of an element and the masses of the element's isotopes.

*Pre-AP Unit 01 Alignment:*

- ❖ Lessons 09–10 introduce students to isotope data, natural abundance, and interpretation of simplified mass spectra.
- ❖ Students learn to calculate weighted average atomic mass from peak height/percent data.
- ❖ They also evaluate how isotope distribution varies across sources, a precursor to using mass spectra to identify unknown samples in AP Chemistry.
- ❖ Graphical reasoning and proportional reasoning are emphasized.

### Topic 1.5 – Atomic Structure and Electron Configuration

1.5.A Represent the ground-state electron configuration of an atom of an element or its ions using the Aufbau principle.

*Pre-AP Unit 01 Alignment:*

- ❖ Lessons 02–03 focus on full electron configurations, energy levels, subshells, and orbital diagrams.
- ❖ Students identify atomic structure (protons, neutrons, electrons) and write configurations using the periodic table.
- ❖ The periodic table puzzle activity reinforces Aufbau, Pauli exclusion, and Hund's rule indirectly by guiding pattern discovery.
- ❖ This forms the foundation for interpreting spectroscopy and bonding patterns in AP Chemistry.

### Topic 1.8 – Valence Electrons and Ionic Compounds

1.8.B: Explain trends in ionic charge and reactivity based on valence electrons and periodicity.

*Pre-AP Unit 01 Alignment:*

- ❖ Lesson 04 teaches shorthand configurations and explicitly identifies valence electrons from the outermost s and p orbitals.
- ❖ Students draw Lewis dot structures and categorize main-group element behavior based on valence patterns.
- ❖ The lesson lays the groundwork for understanding ion formation and ionic charge prediction in AP.

### Topic 2.2 – Intramolecular Forces and Potential Energy

2.2.A: Represent the relationship between potential energy and distance between atoms, based on factors that influence the interaction strength.

*Pre-AP Unit 01 Alignment:*

- ❖ Lessons 05–06 provide a kinesthetic and visual model of electron-nucleus attraction using Coulomb's Law and rubber-band analogies.
- ❖ Students model and discuss how increased electron distance stores energy (potential energy).
- ❖ These conceptual understandings are applied later in AP to model covalent bond length, bond strength, and activation energy curves.

### Topic 2.3 – Structure of Ionic Solids

2.3.A: Represent an ionic solid with a particulate model that is consistent with Coulomb’s law and the properties of the constituent ions.

*Pre-AP Unit 01 Alignment:*

- ❖ While not explicitly modeling lattices, Lessons 05–06 establish charge–distance relationships and set the foundation for attraction-based interactions.
- ❖ Students explain attraction strength between subatomic particles in atoms, which directly parallels the reasoning used to model ion–ion attraction in crystal lattices.

### Topic 2.5 – Lewis Diagrams

2.5.A: Represent a molecule with a Lewis diagram.

*Pre-AP Unit 01 Alignment:*

- ❖ Lesson 04 builds fluency in counting and placing valence electrons for single atoms.
- ❖ Though molecular structures are not yet introduced, the practice of constructing element-level Lewis dot diagrams builds essential symbolic habits that support future molecule-level diagrams.

### Topic 4.4 – Physical and Chemical Changes

4.4.A Explain the relationship between macroscopic characteristics and bond interactions for: (i) chemical processes (ii) physical processes.

*Pre-AP Unit 01 Alignment:*

- ❖ Lessons 05–07 introduce electron excitation and relaxation (quantum jumps), and guide students in reasoning about energy flow into/out of the atom.
- ❖ Students begin distinguishing between changes involving bonding or internal energy and those involving physical states.
- ❖ This prepares them to later distinguish chemical vs. physical changes based on bond involvement.

## VOCABULARY GLOSSARY

Domain-specific words and definitions for this unit.

Key Content Vocabulary	
Term	Definition
Acceleration	Change in velocity.
Accuracy	A measure of how close the average of all trials of for a measured value are to the true value of the measurement.
Analytical Balance	A highly precise instrument used to accurately measure the mass of small samples.
Anchoring Event	Specific instances of a phenomenon that require scholars to pull together a number of science ideas in order to explain.
Atom	The smallest particle of an element.
Atomic Mass Unit (amu)	A unit of mass used to express atomic and molecular weights, equal to one-twelfth of the mass of an atom of carbon-12. One amu is equal to approximately $1.66 \times 10^{-27}$ kg.
Atomic Number (Z)	The number of protons in the nucleus of the atom. This determines the identity of the element of the atom.
Attraction	The non-contact force or interaction that pulls two or more substances or particles toward each other.
Average Atomic Mass	The weighted average of the masses of all naturally occurring isotopes determined by using the natural abundance of each isotope. The molar mass of an element is the same as the average atomic mass determined using the abundance of all naturally occurring isotopes.
Avogadro’s Number	The number of particles found in one mole of a substance with an experimentally determined value of approximately $6.02 \times 10^{23}$ particles per mole.

<b>Balance (Lab Instrument)</b>	A lab instrument that measures the mass.
<b>Bunsen Burner</b>	A device for combining a flammable gas with controlled amounts of air before ignition that produces a hotter flame than would be possible using the ambient air and gas alone.
<b>Charge</b>	The net charge of a particle found by comparing the number of electrons to the number of protons.
<b>Claim</b>	A statement made as an explanation of data collected and analyzed or as an answer to a question.
<b>Control Variable (aka Constant)</b>	Anything that is held constant or limited in an investigation to minimize risk of error in the results.
<b>Conversion Factor</b>	A ratio of equivalent measurements; mainly used in dimensional analysis and stoichiometry.
<b>Core Electrons</b>	Electrons that do not occupy the outermost energy level of an atom; electrons between the nucleus and the valence shell.
<b>Coulomb's Law</b>	Like charges repel; opposite charges attract. The force is proportional to the magnitude of the charges and inversely proportional to the square of the distance between them.
<b>Deflection</b>	Change in direction of movement because of a collision with another object or influence of a field.
<b>Dependent Variable</b>	The variable being tested and measured in an experiment, and is 'dependent' on the independent variable.
<b>Detection</b>	The process of an instrument sensing and reporting the presence of something specific, can be quantitative (numerical value) or qualitative (present/not present).
<b>Dimensional Analysis (aka Factor-Label Method)</b>	An orderly problem-solving process that establishes relationships between different units of measurement through multiplying measured values by one or more known conversion factor(s); the mathematical conversion between an amount in one unit to the corresponding amount in a desired unit through multiplying by one or more conversion factors.
<b>Directly Proportional</b>	When an increase (or decrease) in one quantity causes a proportional increase (or decrease) in the other, maintaining a constant ratio between them.
<b>Electromagnetic (EM) Spectrum</b>	The range of the wavelengths of all possible electromagnetic radiation.
<b>Electromagnetic Wave</b>	A type of radiation that travels in the form of a wave as a result of vibrations between an electric field and a magnetic field.
<b>Electron</b>	Subatomic particle found outside the nucleus of the atom that has negligible mass and a negative charge equal and opposite to the proton.
<b>Electron Cloud</b>	The region of negative charge surrounding an atomic nucleus that is associated with the locations where electrons have greater than 95% probability of existing. Since electrons are always moving it is impossible to know their exact location, only the most likely area they will be located within.
<b>Electron Configuration</b>	The arrangement of electrons around the nucleus of a particular atom or molecule.
<b>Electron Excitation</b>	The process by which atoms absorb and stores energy and causes an electron to quantum jump from the favorable, stable, lowest energy position to a higher energy position farther from the nucleus.
<b>Electron Relaxation</b>	The process by which atoms release stored energy and causes an electron to transition back to its original, favorable, stable, lowest energy position from the higher energy position farther from the nucleus.
<b>Element</b>	Substance that is composed of a single type of atom; a substance that cannot be decomposed by a chemical change; determined by the number of protons in the atom.
<b>Element Symbol</b>	The letter designation for that element that will be found on the periodic table. This is usually one or two letters, with the first letter always being upper case and any subsequent letters present are lower case.
<b>Energy (E)</b>	The capacity to do work, usually measured in Joules (J).
<b>Energy Level (aka Shell)</b>	A fixed distance from the nucleus of an atom where electrons may be found.

<b>Essential Question</b>	A question developed from an anchoring event that is investigated in order to develop an underlying explanatory model for the phenomenon.
<b>Estimation</b>	The process of approximating or making an informed guess about a value or quantity using the information provided without performing precise calculations.
<b>Evidence</b>	Knowledge, facts, or data (qualitative or quantitative) that supports the claim.
<b>Excited State</b>	A state in which an electron quantum jumps to a higher energy position and temporarily occupies an energy state greater than its ground state due to the new electron configuration storing absorbed energy.
<b>Explanatory Model</b>	A proposed explanation made based on limited evidence as a starting point for further investigation.
<b>Frequency (<math>\nu</math>)</b>	The number of times a point on a wave passes a fixed reference point in one second.
<b>Gas (g)</b>	Matter that has an indefinite shape and indefinite volume.
<b>Ground State</b>	The most stable, lowest energy conformation of an atom's electron configuration. All electrons are in their most favorable and lowest energy positions.
<b>Group</b>	Vertical row of the periodic table.
<b>Independent Variable</b>	The variable the experimenter manipulates or changes, and in many cases is assumed to have a direct effect on the dependent variable.
<b>Inference</b>	A conclusion reached on the basis of evidence and reasoning.
<b>Inversely Proportional</b>	When an increase in one quantity leads to a proportional decrease in the other, and vice versa.
<b>Ion</b>	An atom of a single element that has gained or lost electrons, but the number of protons remains the same, causing a positively or negatively charged particle. This is not an oxidation number and the + or – sign is placed behind the number (i.e. 1+ not +1).
<b>Ionization</b>	The process of an atom gaining or losing electrons to become an ion.
<b>Isotope</b>	Atoms that contain the same number of protons but different numbers of neutrons, resulting in atoms of the same element having different masses.
<b>Law of Conservation of Energy</b>	Energy can neither be created nor destroyed - only converted from one form of energy to another.
<b>Law of Conservation of Mass</b>	Matter can neither be created nor destroyed - only converted from one form of matter to another.
<b>Lewis Dot Structure</b>	Simplified model of an atom in the form of a diagram that represents the valence electrons of atoms in a particle.
<b>Liquid (l)</b>	Matter that has an indefinite shape and definite volume.
<b>Mass Number</b>	The number of protons and neutrons in the nucleus of an atom, measured in amu.
<b>Mass Spectrometer</b>	An apparatus for separating isotopes, molecules, and molecular fragments according to mass. The sample is vaporized and ionized, and the ions are accelerated in an electric field and deflected by a magnetic field into a curved trajectory that gives a distinctive mass spectrum.
<b>Mass Spectroscopy</b>	An analytical method useful for measuring the mass-to-charge ratio ( $m/z$ ) of one or more particles present in a sample.
<b>Mass Spectrum</b>	A graphical representation of the mass distribution of a sample of particles analyzed by a mass spectrometer. Particles with the same mass are represented in peaks, and the relative height of those peaks represent the relative abundance of particles with that mass.
<b>Mass</b>	The amount of matter present; measured in the base SI unit of grams (g).
<b>Meters</b>	The SI unit of length, abbreviated "m".

<b>Mixture</b>	Consists of two or more chemically distinct components that do not react with each other and retain their original properties.
<b>Molar Mass</b>	The mass, in grams, of one mole of a substance expressed in units of grams per mole (g/mol). The average atomic mass determined using the natural abundance of all isotopes of an element is the same as the molar mass of an element.
<b>Mole</b>	A way to count the number of particles of a substance by group, similar to a “pair” or a “dozen”; the amount of substance containing the same number of atoms, molecules, ions, or other entities as the number of atoms in exactly 12 grams of $^{12}\text{C}$ .
<b>Nanometers</b>	A modified version of the SI unit of length and the definition of the prefix nano-, abbreviated “nm”.
<b>Neutron</b>	Subatomic particle found in the nucleus of the atom that has an approximate mass of 1 amu that is neutral (no charge).
<b>Nucleus</b>	The small, dense region consisting of protons and neutrons at the center of an atom.
<b>Observation</b>	Any data collected using any of the five senses, can be quantitative or qualitative.
<b>Octet Rule</b>	The tendency of atoms to prefer to have eight electrons in the valence shell.
<b>Orbital</b>	An orbital is a three-dimensional description of the most likely location of an electron around an atom.
<b>Particle</b>	Any basic unit of matter such as atoms, ions, molecules, formula units, etc.
<b>Particulate Diagram</b>	A visual representation in chemistry that depicts the microscopic structure of matter, usually using small circles or spheres to represent atoms or molecules, showing their arrangement and relative numbers within a substance, allowing for visualization of states of matter (solid, liquid, gas) and chemical reactions by illustrating the substances involved in chemical and physical processes.
<b>Percent Abundance</b>	The proportion of an isotope species relative to all other isotopes of that element in the nature in percentage form.
<b>Period</b>	Horizontal row of the periodic table.
<b>Phase (aka State of Matter)</b>	A distinct form of matter based on its homogeneity and physical properties.
<b>Phenomenon</b>	Events or processes (“things that happen”) that are observable by the senses, or detectable by instruments.
<b>Photon Emission</b>	The process of elements releasing different photons of color as their atoms return to their ground state.
<b>Photon</b>	A fundamental particle that exist as waves of electromagnetic radiation and are the smallest measurable increment of electromagnetic energy.
<b>Planck’s Constant (h)</b>	A fundamental physical constant of electromagnetic radiation that is used to relate the energy of a photon to its frequency and is always equal to $6.6 \times 10^{-34}$ J·s.
<b>Potential Energy</b>	Stored energy based on position.
<b>Precision</b>	A measure of how close all trials for a measured value are to one another.
<b>Prefix</b>	A word, letter, or number placed before the root word; in chemistry it can communicate the quantity present (naming compounds) or modify the value of the root word (unit prefixes).
<b>Proton</b>	Subatomic particle found in the nucleus of the atom that has an approximate mass of 1 amu and positive charge equal and opposite to the electron.
<b>Pure Substance</b>	A single type of matter that cannot be separated into other kinds of matter by any physical means.
<b>Qualitative</b>	The determination of non-numerical information about a chemical species, a reaction, a system, etc.
<b>Quantitative</b>	The determination of numerical information about a chemical species, a reaction, a system, etc.
<b>Quantum Jump</b>	The abrupt transition of an electron from one position to another, such as ground state to excited state configuration.

<b>Random Error</b>	An unpredictable, chance variation in a measurement that can occur due to inconsistent application of the procedure or other variables.
<b>Ratio</b>	Numerical comparison or relationship between two or more values.
<b>Reasoning</b>	The explanation of the “how” or “why” the evidence you have chosen supports your claim.
<b>Relative Abundance</b>	The proportion of an isotope species relative to all other isotopes of that element in the nature in decimal form.
<b>Repulsion</b>	The non-contact force or interaction that pushes two or more substances or particles away from each other.
<b>Shell (Energy Level)</b>	A fixed distance from the nucleus of an atom where electrons may be found.
<b>Solid (s)</b>	Matter that has a definite shape and a definite volume.
<b>Subshell</b>	The division of energy levels (such as $n=1$ , $n=2$ , and so on) into distinct shells of distinct positions different orbital types will occupy (1s, 2p, 3d, etc.).
<b>Systematic Error</b>	Errors that result from predictable changes in an experiment; errors that causes all measured quantities to be off by the same amount or the same proportion usually resulting in decreased investigative accuracy.
<b>Trend</b>	A recognizable pattern in a data set that communicates information about the data collected and associated processes.
<b>Valence Electron</b>	An electron located in the outermost shell (or valence shell) of an atom.
<b>Visible Light Spectrum</b>	The segment of the electromagnetic spectrum that the human eye can view, organized from lowest to highest energy using the anagram ROYGBIV (red, orange, yellow, green, blue, indigo, violet).
<b>Volume</b>	The amount of space occupied by a substance, typically expressed in liters (L).
<b>Wavelength (<math>\lambda</math>)</b>	The distance between any given point in a wave cycle and the same point in the next wave cycle.
<b>Weigh Boat</b>	Open containers that is used to mass granulated, liquid, or solid samples.
<b>Weighted Average</b>	A weighted average is the average of a data set that recognizes certain numbers as more frequent or more influential than others; found by multiplying the value of each quantity being averaged by the decimal form of the percent abundance of that quantity.