

PHYSICAL SETTING/CHEMISTRY

CONTENT CONNECTIONS TABLE

STANDARD 4: The Physical Setting

The Content Connections Table has been designed to assist teachers in curriculum writing and lesson planning. Some of the listed major understandings have a related skill and/or real-world connection to a specific content focus area. The scope of the content connections and skills is not meant to be limited; i.e., a skill may be connected to more than one major understanding.

Additionally, real-world connections have been identified only to assist teachers in planning and are not meant to link these connections to any assessment.

Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Students enrolled in Chemistry Regents will be responsible for the additional Major understandings, Skills and Real World Connections indicated with "Above Core – R".

Students enrolled in Chemistry Honors will be responsible for the additional Major understandings, Skills and Real World Connections indicated with "Above Core – H" as well as those designated as "Above Core – R".

KEY	LINK TO APPENDIX A	MAJOR UNDERSTANDINGS	SKILLS The student should be able to:	REAL-WORLD CONNECTIONS
I. Atomic Concepts				
3.1a	I.1	3.1a The modern model of the atom has evolved over a long period of time through the work of many scientists. Above Core – R: Historical contributions of Dalton, Thomson, Rutherford, Bohr and the development of the current atomic (quantum mechanical) model.	relate experimental evidence (given in the introduction of Key Idea 3) to models of the atom (3.1ii) Above Core – H: Solve quantitative problems using the law of Multiple and Definite Proportions.	
3.1b	I.2	3.1b Each atom has a nucleus, with an overall positive charge, surrounded by negatively charged electrons.	use models to describe the structure of an atom (3.1i)	
3.1c	I.3	3.1c Subatomic particles contained in the nucleus include protons and neutrons. Above Core – R: Protons and neutrons are divisible into smaller parts. Above core – H: Quarks and Leptons		

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3.1d	I.4	3.1d The proton is positively charged, and the neutron has no charge. The electron is negatively charged.	Above Core – H: Determine the charge on an electron based on the Milikan oil drop experiment.	
3.1e	I.5	3.1e Protons and electrons have equal but opposite charges. The number of protons is equal to the number of electrons in an atom. Above Core – R: Atomic # = # of protons Mass # = # of protons + # of neutrons # of electrons = # of protons in an atom	determine the number of protons or electrons in an atom or ion when given one of these values (3.1iii)	
3.1f	I.6	3.1f The mass of each proton and each neutron is approximately equal to one atomic mass unit. An electron is much less massive than a proton or neutron. Above Core – H: Relative verses actual mass	calculate the mass of an atom, the number of neutrons or the number of protons, given the other two values (3.1iv)	♦ lasers Above Core – H: Mass spectrometer
3.1g	II.2	The number of protons in an atom (atomic number) identifies the element. The sum of the protons and neutrons in an atom (mass number) identifies an isotope. Common notations that represent isotopes include: ^{14}C , ^{14}C , carbon-14, C-14.	interpret and write isotopic notation (3.1x) Above Core – R: utilize mass # and atomic # to determine # of subatomic particles in atoms and ions.	
3.1h	I.7	In the wave-mechanical model (electron cloud), the electrons are in orbitals, which are defined as regions of most probable electron location (ground state). Above Core – R: Each electron within the atom specified by PEL, sublevel, orbital and spin. Shapes of s & p orbitals.	Above Core – H: write and interpret quantum mechanical electron distributions using the four quantum numbers n, l, m, s calculate values of n,l,m,s	

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3.1i	I.8	<p>Each electron in an atom has its own distinct amount of energy.</p> <p>Above Core – R: Wave /Particle Duality, Heisenburg Uncertainty Principle Pauli Exclusion Principle Aufbau Principle Hund’s Rule</p> <p>Above Core – H: DeBroglie Hypothesis Plank’s Hypothesis</p>	<p>Above Core – R: write and interpret Bohr, Quantum-Mechanical and short-hand (Kernal/Noble Gas). e⁻ configurations (ground and excited) for atoms and ions</p> <p>Above Core – H: solve problems using the following:</p> $E = mc^2$ $E = v\lambda$ $E_n = \frac{-2.18 \times 10^{-18}}{n^2}$	<p>Above Core – H: Free electron lasers Photoelectric Effect</p>
3.1j	I.9	<p>When an electron in an atom gains a specific amount of energy, the electron is at a higher energy state (excited state).</p>	<p>distinguish between ground state and excited state electron configurations, e.g., 2-8-2 vs. 2-7-3 (3.1v)</p> <p>Above Core – R: Bohr e⁻ distribution → Quantum-mechanical e⁻ distribution: 1s²2s²2p⁶3s² vs. 1s²2s²2p⁶3s¹3p¹</p>	
3.1k	I.10	<p>When an electron returns from a higher energy state to a lower energy state, a specific amount of energy is emitted. This emitted energy can be used to identify an element.</p>	<p>identify an element by comparing its bright-line spectrum to given spectra (3.1vi)</p> <p>Above Core – H: calculate the Energy, Wavelength, or Frequency of spectral lines</p>	<ul style="list-style-type: none"> ◆ flame tests ◆ neon lights ◆ fireworks ◆ forensic analysis ◆ spectral analysis of stars

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3.1l	I.11	The outermost electrons in an atom are called the valence electrons. In general, the number of valence electrons affects the chemical properties of an element.	draw a Lewis electron-dot structure of an atom (3.1viii) distinguish between valence and non-valence electrons, given an electron configuration, e.g., 2-8-2 (3.1vii). Above Core – R: the same skill is required for ions and for quantum mechanical e-configurations. Above Core – H: draw Lewis e ⁻ dot structures to represent hybridized orbitals and molecules that violate the octet rule.	
3.1m	I.12	Atoms of an element that contain the same number of protons but a different number of neutrons are called isotopes of that element.		
3.1n	I.13	The average atomic mass of an element is the weighted average of the masses of its naturally occurring isotopes. Above Core – R: Distinguish between mass # & atomic mass	given an atomic mass, determine the most abundant isotope (3.1xi). calculate the atomic mass of an element, given the masses and ratios of naturally occurring isotopes (3.1xii).	
I I . P e r i o d i c T a b l e				
3.1y	II.1	The placement or location of an element on the Periodic Table gives an indication of physical and chemical properties of that element. The elements on the Periodic Table are arranged in order of increasing atomic number. Above Core – R: Groups and Periods Historical contributions of Mendeleev, Mosley. Above Core – H: Historical contributions of Dobereiner, Newlands	explain the placement of an unknown element in the Periodic Table based on its properties (3.1xvi)	♦ similar properties and uses for elements in the same family ♦ characteristics of a class of elements are similar

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3.1v	II.3	<p>Elements can be classified by their properties, and located on the Periodic Table, as metals, nonmetals, metalloids (B, Si, Ge, As, Sb, Te) , and noble gases.</p> <p>Above Core – R: Group 1 elements – alkali metals Group 2 elements – Alkaline Earth Metals Group 3-12 elements – Transition Elements Group 17 elements – Halogens Group 18 elements – Noble or Inert Gases</p> <p>Above Core – H: Descriptive chemistry of Hydrogen, Alkali metals, Alkaline Earth metals, Nitrogen/Phosphorus group, Oxygen group, Halogens, Nobel gases, and Transition elements.</p>	<p>classify elements as metals, nonmetals, metalloids, or noble gases by their properties (3.1xiii)</p> <p>Above Core – R: classify elements as members of specific families (alkali metals, alkaline earth metals, transition elements, halogens, or noble gases) based on properties.</p> <p>identify elements that form colored aqueous solutions (transition elements).</p>	<p>♦ similar properties and uses for elements in the same family</p> <p>Above Core – H: ⁹⁰Sr hazard at Chernobyl</p>
3.1w	II.4	<p>Elements can be differentiated by their physical properties. Physical properties of substances, such as density, conductivity, malleability, solubility, and hardness, differ among elements.</p>	<p>describe the states of the elements at STP (3.1xviii)</p> <p>Above Core – R: identify the 7 elements that are diatomic in nature.</p>	<p>♦ uses of different elements, e.g., use of semiconductors in solid state electronics and computer technology</p> <p>♦ alloys as superconductors</p> <p>Above Core – H: Charged coupled devices, and the Hubble telescope</p> <p>Allergies and cyclopentamine</p>
3.1x	II.5	<p>Elements can be differentiated by chemical properties. Chemical properties describe how an element behaves during a chemical reaction.</p>		<p>♦ metallurgy</p> <p>♦ recovery of metals</p> <p>Above Core – H: Steel vs. Aluminum cans: Density/Malleability</p>
5.2f	II.6	<p>Some elements exist as two or more forms in the same phase. These forms differ in their molecular or crystal structure, and hence in their properties.</p>		<p>♦ different properties for each allotrope: oxygen gas vs. ozone, coal vs. graphite vs. diamond vs. Buck-Minster fullerene</p> <p>Above Core – H: CVD Diamonds</p>

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3.1z	II.7	<p>For Groups 1, 2, and 13-18 on the Periodic Table, elements within the same group have the same number of valence electrons (helium is an exception) and therefore similar chemical properties.</p> <p>Above Core – R: Strength of coulombic attraction depends on distance and magnitude.</p> <p>Elements in the same group have the same # of valence e⁻ but increasing # of occupied PEL's going from top to bottom within the group.</p> <p>Elements in the same period have the same # of occupied PEL's but an increasing # of valence e⁻ going from left to right across the PT.</p>	<p>determine the group of an element, given the chemical formula of a compound, e.g., XCl or XCl₂ (3.1xv)</p> <p>Above Core – R: determine the group and period of an element based on e⁻ configuration.</p> <p>compare and contrast properties of elements within a group or a period for Groups 1, 2, 13-18 on the Periodic Table</p>	
3.1aa	II.8	<p>The succession of elements within the same group demonstrates characteristic trends: differences in atomic radius, ionic radius, electronegativity, first ionization energy, metallic/nonmetallic properties.</p> <p>Above Core – R: electron affinity</p>	<p>Above Core – R: explain trends within a group based on electron configurations and coulombic attraction.</p> <p>Above Core – H: prediction based on the quantum-mechanical e⁻ distribution including the transition elements.</p>	
3.1bb	II.9	<p>The succession of elements across the same period demonstrates characteristic trends: differences in atomic radius, ionic radius, electronegativity, first ionization energy, metallic/nonmetallic properties.</p> <p>Above Core – R: electron affinity</p>	<p>Above Core – R: explain trends within a period based on electron configurations and coulombic attraction.</p> <p>write and interpret isoelectronic series based on the octet rule.</p> <p>Above Core – H: prediction based on the quantum-mechanical e⁻ distribution including the transition elements</p>	

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III. Moles/Stoichiometry				
3.1cc	III.1	A compound is a substance composed of two or more different elements that are chemically combined in a fixed proportion. A chemical compound can be broken down by chemical means. A chemical compound can be represented by a specific chemical formula and assigned a name based on the IUPAC system.	Above Core – R: name and write formulas for ionic and molecular compounds based on the stock system. interpret chemical formulas microscopically (ratio of atoms) and macroscopically (molar ratios).	◆ reading food and beverage labels (consumer Chemistry)
3.1ee	III.2	Types of chemical formulas include: empirical, molecular, and structural. Above Core – R: condensed structural		
3.3d	III.3	The empirical formula of a compound is the simplest whole-number ratio of atoms of the elements in a compound. It may be different from the molecular formula, which is the actual ratio of atoms in a molecule of that compound.	determine the molecular formula, given the empirical formula and molecular mass (3.3vii) determine the empirical formula from a molecular formula (3.3v) Above Core – R: Determine the empirical and molecular formula of an unknown from quantitative data such as % composition by mass.	Above Core – R: Use of Mass Spectroscopy in Forensic Investigation
3.3a	III.4	In all chemical reactions there is a conservation of mass, energy, and charge.	interpret balanced chemical equations in terms of conservation of matter and energy (3.3ii)	

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3.3c	III.5	A balanced chemical equation represents conservation of atoms. The coefficients in a balanced chemical equation can be used to determine mole ratios in the reaction.	<p>balance equations, given the formulas for reactants and products (3.3i)</p> <p>interpret balanced chemical equations in terms of conservation of matter and energy (3.3ii)</p> <p>create and use models of particles to demonstrate balanced equations (3.3iii)</p> <p>calculate simple mole-mole stoichiometry problems, given a balanced equation (3.3iv)</p> <p>Above Core – R: calculate the amount of product produced or reactant needed such as Mass/ Mass and % water/hydrate.</p> <p>Above Core – H: calculate the amount of product produced or reactant needed such as Mass/Volume, Volume/ Volume problems, Limiting reactant problems, % Yield</p>	Above Core – H: Photosynthesis vs. Respiration
3.3e	III.6	The formula mass of a substance is the sum of the atomic masses of its atoms. The molar mass (gram-formula mass) of a substance equals one mole of that substance.	calculate the formula mass and the gram-formula mass (3.3viii)	

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3.3f	III.7	<p>The percent composition by mass of each element in a compound can be calculated mathematically.</p> <p>Above Core – R: One mole contains 6.02×10^{23} particles (Avagadro's #)</p>	<p>determine the number of moles of a substance, given its mass (3.3ix)</p> <p>determine the mass of a given number of moles of a substance (3.3vi)</p> <p>Above Core – R: use the factor/label method of problem solving, unit analysis, scientific notation, significant figures, periodic table and a scientific calculator for the inter-conversion of measured or calculated quantities of an element or compound as follows: Mass (g) ↔ Moles (mol) ↔ # of particles (atoms) or (molecules) ↔ Volume of a gas @ constant temperature and pressure (L)</p>	
3.2b	III.8	<p>Types of chemical reactions include synthesis, decomposition, single replacement, and double replacement.</p> <p>Above Core – R: Combustion, Dissociation, Ionization</p>	<p>identify types of chemical reactions (3.2ii)</p> <p>Above Core – R: write total and net ionic equations for double replacement reactions</p> <p>identify spectator ions.</p>	<ul style="list-style-type: none"> ◆ recovery of metals from ores ◆ electroplating ◆ corrosion ◆ precipitation reactions ◆ dangers of mixing household chemicals together (e.g., bleach and ammonia) ◆ electrolysis of active metal compounds ◆ explosives (inflation of air bags)
IV. Chemical Bonding				
3.1dd	IV.1	Compounds can be differentiated by their chemical and physical properties.	distinguish among ionic, molecular, and metallic substances, given their properties (3.1xix)	
5.2g	IV.2	Two major categories of compounds are ionic and molecular (covalent) compounds.		

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5.2a	IV.3	Chemical bonds are formed when valence electrons are: transferred from one atom to another (ionic); shared between atoms (covalent); mobile within a metal (metallic).	demonstrate bonding concepts using Lewis dot structures representing valence electrons: transferred (ionic bonding); shared (covalent bonding); in a stable octet (5.2i)	<ul style="list-style-type: none"> ◆ photosynthesis ◆ DNA bonding
5.2e	IV.4	<p>In a multiple covalent bond, more than one pair of electrons are shared between two atoms. Unsaturated organic compounds contain at least one double or triple bond.</p> <p>Above Core – H: When bonding covalently, groups 2, 13, and 14 exhibit hybridized orbital interaction</p>	<p>Above Core – H: Write hybridized e⁻ dot diagrams and three dimensional models to explain the bonding and resultant shape and polarity of sp, sp², and sp³ hybridized orbitals.</p> <p>Describe shape and geometry of the orbital overlaps that result in sigma (σ) and pi (π) bonds</p>	
5.2l	IV.5	<p>Molecular polarity can be determined by the shape and distribution of the charge. Symmetrical (nonpolar) molecules include CO₂, CH₄, and diatomic elements. Asymmetrical (polar) molecules include HCl, NH₃, H₂O.</p> <p>Above Core – R: Distinguish between Intramolecular and Intermolecular forces of attraction.</p>	<p>Above Core – R: use the shape of the molecule to predict the type of intermolecular force as follows:</p> <p>Van der Waal's (London dispersion) forces, Dipole – Dipole interactions, Hydrogen bonds.</p>	Above Core – R: Hydrogen Bonds and the atypical behavior of water.
5.2c	IV.6	When an atom gains one or more electrons, it becomes a negative ion and its radius increases. When an atom loses one or more electrons, it becomes a positive ion and its radius decreases.		◆ saturated vs. unsaturated compounds— health connections
5.2i	IV.7	When a bond is broken, energy is absorbed. When a bond is formed, energy is released.		
5.2b	IV.8	<p>Atoms attain a stable valence electron configuration by bonding with other atoms. Noble gases have stable valence electron configurations and tend not to bond.</p> <p>Above Core – R: Bonding & Stability based on octet rule.</p>	determine the noble gas configuration an atom will achieve when bonding (5.2iv)	

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5.2n	IV.9	Physical properties of substances can be explained in terms of chemical bonds and intermolecular forces. These properties include conductivity, malleability, solubility, hardness, melting point, and boiling point.	Above Core – R: comparison of the physical properties of: Molecular solids Network solids Ionic solids Metallic solids	
5.2d	IV.10	Electron-dot diagrams (Lewis structures) can represent the valence electron arrangement in elements, compounds, and ions. Above Core – R: Use VSEPR theory to determine the three dimensional shape of covalent molecules.	demonstrate bonding concepts, using Lewis dot structures representing valence electrons: transferred (ionic bonding); shared (covalent bonding); in a stable octet (5.2i) Above Core – R: use VSEPR theory to build models and resultant Lewis e ⁻ dot structures for covalent molecules and polyatomic ions that obey the octet rule and determine resultant polarity. Above Core – H: The same skill is required for molecules and polyatomic ions that do not obey the octet rule	♦ free radicals
5.2j	IV.11	Electronegativity indicates how strongly an atom of an element attracts electrons in a chemical bond. Electronegativity values are assigned according to arbitrary scales.	Above Core – R: utilize electronegativity difference to determine bond character (non polar covalent, polar covalent, ionic).	
5.2k	IV.12	The electronegativity difference between two bonded atoms is used to assess the degree of polarity in the bond.	distinguish between nonpolar covalent bonds (two of the same nonmetals) and polar covalent bonds (5.2v)	

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5.2h	IV.13	Metals tend to react with nonmetals to form ionic compounds. Nonmetals tend to react with other nonmetals to form molecular (covalent) compounds. Ionic compounds containing polyatomic ions have both ionic and covalent bonding.	Above core – R: predict the type of bonding that will occur between elements Above Core – H: The same skill is required using quantitative data. calculation of Ionic radii, Covalent radii, Van der Waal's radii, and Bond length	
V. Physical Behavior of Matter				
3.1q	V.1	Matter is classified as a pure substance or as a mixture of substances.	Above Core – R: Classify real substances as pure matter, homogeneous mixtures, or heterogeneous mixtures.	
3.1kk	V.2	The three phases of matter (solids, liquids, and gases) have different properties.	use a simple particle model to differentiate among properties of a solid, a liquid, and a gas (3.1xxii)	<ul style="list-style-type: none"> ◆ common everyday examples of solids, liquids, and gases ◆ nature of H₂O in our environment ◆ solids – metallic, crystalline, amorphous (quartz glass, opals), solid state ◆ liquids – surface tension, capillary, viscosity ◆ gases – real and ideal gases <p>Above Core – H: semiconductors, hydrated crystals, liquid crystals</p>
3.1r	V.3	A pure substance (element or compound) has a constant composition and constant properties throughout a given sample, and from sample to sample.	use particle models/diagrams to differentiate among elements, compounds, and mixtures (3.1xxxvi)	
3.1u	V.4	Elements are substances that are composed of atoms that have the same atomic number. Elements cannot be broken down by chemical change.		

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3.1s	V.5	Mixtures are composed of two or more different substances that can be separated by physical means. When different substances are mixed together, a homogeneous or heterogeneous mixture is formed.		<ul style="list-style-type: none"> ◆ alloys ◆ separation by filtration, distillation, desalination, crystallization, extraction, chromatography ◆ water quality testing ◆ colloids ◆ emulsifiers (making ice cream) ◆ sewage treatment
3.1t	V.6	The proportions of components in a mixture can be varied. Each component in a mixture retains its original properties.		
3.1nn	V.7	Differences in properties such as density, particle size, molecular polarity, boiling point, freezing point, and solubility permit physical separation of the components of the mixture.	describe the process and use of filtration, distillation, and chromatography in the separation of a mixture (3.1xxiv)	
3.1oo	V.8	A solution is a homogeneous mixture of a solute dissolved in a solvent. The solubility of a solute in a given amount of solvent is dependent on the temperature, the pressure, and the chemical natures of the solute and solvent.	<p>interpret and construct solubility curves (3.1xxv)</p> <p>use solubility curves to distinguish among saturated, supersaturated and unsaturated solutions (3.1xxviii)</p> <p>apply the adage "like dissolves like" to real-world situations (3.1xxvi)</p>	<ul style="list-style-type: none"> ◆ degrees of saturation of solutions ◆ dry cleaning

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3.1pp	V.9	<p>The concentration of a solution may be expressed as: molarity (M), percent by volume, percent by mass, or parts per million (ppm).</p> <p>Above Core – R: Qualitative expression – dilute vs. concentrated</p>	<p>describe the preparation of a solution, given the molarity (3.1xxx)</p> <p>interpret solution concentration data (3.1xxx)</p> <p>calculate solution concentrations in molarity (M), percent mass, and parts per million (ppm) (3.1xxix)</p> <p>Above Core – H: Quantitative calculation of the following solution [] Mole fraction/Mole % Mass fraction/mass % Molality Boiling point elevation Freezing point depression Molecular mass determination from BPE and FPD Osmotic pressure (Colligative Properties)</p>	
3.1qq	V.10	<p>The addition of a nonvolatile solute to a solvent causes the boiling point of the solvent to increase and the freezing point of the solvent to decrease. The greater the concentration of solute particles the greater the effect.</p>		<ul style="list-style-type: none"> ◆ salting an icy sidewalk ◆ ice cream making ◆ antifreeze/ engine coolant ◆ airplane deicing ◆ cooking pasta
4.1a	V.11	<p>Energy can exist in different forms, such as chemical, electrical, electromagnetic, thermal, mechanical, and nuclear.</p>		<p>Above Core – H: Conversion techniques of sea water to potable water</p>
4.2a	V.12	<p>Heat is a transfer of energy (usually thermal energy) from a body of higher temperature to a body of lower temperature. Thermal energy is associated with the random motion of atoms and molecules.</p>	<p>distinguish between heat energy and temperature in terms of molecular motion and amount of matter (4.2i)</p> <p>qualitatively interpret heating and cooling curves in terms of changes in kinetic and potential energy, heat of vaporization, heat of fusion, and phase changes (4.2iii)</p>	

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4.2b	V.13	Temperature is a measure of the average kinetic energy of the particles in a sample of matter. Temperature is not a form of energy.	<p>distinguish between heat energy and temperature in terms of molecular motion and amount of matter (4.2i)</p> <p>explain phase changes in terms of the changes in energy and intermolecular distance (4.2ii)</p> <p>convert temperatures in Celsius degrees (°C) to Kelvins (K), and Kelvins to Celsius degrees (3.4iii)</p>	
3.4a	V.14	The concept of an ideal gas as a model to explain behavior of gases. A real gas is most like an ideal gas when the real gas is at low pressure and high temperature.	<p>Above Core – R: explain deviations from ideal gas behavior</p> <p>identify real gases that behave most like ideal gases at STP</p> <p>predict conditions of T & P under which real gases behave most like ideal gases.</p>	<ul style="list-style-type: none"> ◆ Earth's primitive atmosphere ◆ use of models to explain something that cannot be seen
3.4b	V.15	Kinetic molecular theory (KMT) for an ideal gas states all gas particles: ◆ are in random, constant, straight-line motion ◆ are separated by great distances relative to their size; the volume of gas particles is considered negligible ◆ have no attractive forces between them ◆ have collisions that may result in a transfer of energy between particles, but the total energy of the system remains constant.		
3.4d	V.16	Collision theory states that a reaction is most likely to occur if reactant particles collide with the proper energy and orientation.	Above Core – R: use collision theory to explain reaction rates.	

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3.4c	V.17	<p>Kinetic molecular theory describes the relationships of pressure, volume, temperature, velocity, and frequency and force of collisions among gas molecules.</p> <p>Above Core – R: Units of pressure include KPa, Torr, mmHg, atm</p> <p>Comparison of Ideal vs. Real gas behavior in terms of Pressure, Temperature, and Molecular mass.</p> <p>Graphic interpretation of Boyle’s Law, Charles Law, Gay-Lussac’s Law.</p> <p>Dalton’s Law of partial pressures</p> <p>Graham’s Law of gas effusion</p> <p>Above Core – H: Open and closed manometers are used to measure the pressure of a gas</p> <p>Mathematical derivation of Boyle’s Law, Charles Law, Gay-Lussac’s Law, Dalton’s Law, Graham’s Law, Ideal gas equation</p>	<p>explain the gas laws in terms of KMT (3.4i)</p> <p>solve problems, using the combined gas law (3.4ii)</p> <p>Above Core – R: using dimensional analysis, convert units of pressure</p> <p>solve quantitative and qualitative problems using the following: Boyle’s Law Charles Law Gay-Lussac’s Law Dalton’s Law Ideal gas equation Graham’s Law</p> <p>Above Core – H: Solve quantitative problems of gas pressure from experimental data using open and closed manometers.</p> <p>$KE = \frac{1}{2} mv^2$</p>	<p>♦ structure and composition of Earth's atmosphere (variations in pressure and temperature)</p> <p>Above Core – H: Quantitative determination of absolute zero</p> <p>Ammonia fountain</p> <p>Boiling water with ice</p> <p>Uranium – 235 enrichment from Uranium – 238 by its greater rate of diffusion; Used by Iraq to produce weapons grade uranium</p>
3.4e	V.18	<p>Equal volumes of gases at the same temperature and pressure contain an equal number of particles. (Avagadro’s Law)</p>		
4.2c	V.19	<p>The concepts of kinetic and potential energy can be used to explain physical processes that include: fusion (melting); solidification (freezing); vaporization (boiling, evaporation), condensation, sublimation, and deposition.</p>	<p>qualitatively interpret heating and cooling curves in terms of changes in kinetic and potential energy, heat of vaporization, heat of fusion, and phase changes (4.2iii)</p> <p>calculate the heat involved in a phase or temperature change for a given sample of matter (4.2iv)</p> <p>explain phase change in terms of the changes in energy and intermolecular distances (4.2ii)</p>	<p>♦ weather processes</p> <p>♦ greenhouse gases</p>

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3.2a	V.20	A physical change results in the rearrangement of existing particles in a substance. A chemical change results in the formation of different substances with changed properties.		
4.1b	V.21	Chemical and physical changes can be exothermic or endothermic.	distinguish between endothermic and exothermic reactions, using energy terms in a reaction equation, ΔH , potential energy diagrams or experimental data (4.1i) Above Core – R: qualitatively and quantitatively describe the energy changes associated with chemical changes in a calorimeter.	♦ calorimetry
3.1j	V.22	The structure and arrangement of particles and their interactions determine the physical state of a substance at a given temperature and pressure.	use a simple particle model to differentiate among properties of solids, liquids, and gases (3.1xxii)	
5.2m	V.23	Intermolecular forces created by the unequal distribution of charge result in varying degrees of attraction between molecules. Hydrogen bonding is an example of a strong intermolecular force.	explain vapor pressure, evaporation rate, and phase changes in terms of intermolecular forces (5.2iii)	♦ refrigeration ♦ meniscus (concave/convex) ♦ capillary action ♦ surface tension Above Core – H: CFC's and the depletion of ozone Adiabatic expansion Rain-X and Hydrophobic monomolecules
5.2n	V.24	Physical properties of substances can be explained in terms of chemical bonds and intermolecular forces. These properties include conductivity, malleability, solubility, hardness, melting point, and boiling point.	compare the physical properties of substances based upon chemical bonds and intermolecular forces (5.2ii)	

KEY	LINK TO APPENDIX A	MAJOR UNDERSTANDINGS	SKILLS The student should be able to:	REAL-WORLD CONNECTIONS
VI Kinetics / Equilibrium				
3.4d	VI.1	Collision theory states that a reaction is most likely to occur if reactant particles collide with the proper energy and orientation.	use collision theory to explain how various factors, such as temperature, surface area, and concentration, influence the rate of reaction (3.4vi)	♦ synthesis of compounds
3.4f	VI.2	The rate of a chemical reaction depends on several factors: temperature, concentration, nature of reactants, surface area, and the presence of a catalyst.	Above Core – R: predict overall affect on reaction rate by manipulating variables. Above Core – H: Rate Laws and Reaction order $R = k [R]$ Thermodynamic sability vs. Kinetic stability	♦ catalysts and inhibitors
3.4h	VI.3	Some chemical and physical changes can reach equilibrium.	identify examples of physical equilibria as solution equilibrium and phase equilibrium, including the concept that a saturated solution is at equilibrium (3.4 vii).	♦ balloons
3.4i	VI.4	At equilibrium the rate of the forward reaction equals the rate of the reverse reaction. The measurable quantities of reactants and products remain constant at equilibrium. Above Core – R: Temperature is the only variable that affects the value of K_{eq}	describe the concentration of particles and rates of opposing reactions in an equilibrium system (3.4iv) Above Core – R: Quantitative calculation of the Equilibrium constant K_{eq} (Mass-Action Expression)	
3.4j	VI.5	LeChatelier's principle can be used to predict the effect of stress (change in pressure, volume, concentration, and temperature) on a system at equilibrium.	qualitatively describe the effect of stress on equilibrium, using LeChatelier's principle (3.4v) Above Core – R: Common Ion Effect	♦ Haber process

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4.1c	VI.6	Energy released or absorbed by a chemical reaction can be represented by a potential energy diagram.	read and interpret potential energy diagrams: PE of reactants and products, activation energy (with or without a catalyst), heat of reaction (4.1ii). Above Core – R: generate PE diagrams that include all of the above including activated complex. Above Core – H: Read and interpret plots of [reactant] and [product] vs. time.	
4.1d	VI.7	Energy released or absorbed by a chemical reaction (heat of reaction) is equal to the difference between the potential energy of the products and the potential energy of the reactants. Above Core – R: The sign (+/-) of ΔG determines spontaneity.	Above Core – R: solve quantitative calculations and qualitatively interpret solutions to the Gibb's free energy equation $\Delta G = \Delta H - T\Delta S$	<ul style="list-style-type: none"> ◆ burning fossil fuels ◆ photosynthesis ◆ production of photo-chemical smog Above Core – H: Solar darkening sunglasses as a reversible reaction
3.4g	VI.8	A catalyst provides an alternate reaction pathway which has a lower activation energy than an uncatalyzed reaction.		◆ enzymes in the human body
3.1ll	VI.9	Entropy is a measure of the randomness or disorder of a system. A system with greater disorder has greater entropy.	compare the entropy of phases of matter (3.1xxiii)	◆ relationship to phase change
3.1mm	VI.10	Systems in nature tend to undergo changes toward lower energy and higher entropy.		◆ chaos theory — randomness vs. order

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VII. Organic Chemistry				
3.1ff	VII.1	Organic compounds contain carbon atoms which bond to one another in chains, rings, and networks to form a variety of structures. Organic compounds can be named using the IUPAC system.	classify an organic compounds based on their structural or condensed structural formula (3.1xvii) Above Core – R: Name organic compounds using the IUPAC system.	<ul style="list-style-type: none"> ◆ biochemical molecules-formation of carbohydrates, proteins, starches, fats, nucleic acids ◆ synthetic polymers-polyethylene (plastic bags, toys), polystyrene (cups, insulation), polypropylene (carpets, bottles) polytetrafluoroethylene (nonstick surfaces—Teflon™), polyacrylonitrile (yarns, fabrics, wigs) ◆ disposal problems of synthetic polymers
3.1gg	VII.2	Hydrocarbons are compounds that contain only carbon and hydrogen. Saturated hydrocarbons contain only single carbon-carbon bonds. Unsaturated hydrocarbons contain at least one multiple carbon-carbon bond.	draw structural formulas for alkanes, alkenes, and alkynes containing a maximum of ten carbon atoms (3.1xxi)	
3.1hh	VII.3	Organic acids, alcohols, esters, aldehydes, ketones, ethers, halides, amines, amides, and amino acids are types of organic compounds that differ in their structures. Functional groups impart distinctive physical and chemical properties to organic compounds.	classify an organic compound based on its structural or condensed structural formula (3.1xvii) draw a structural formula with the functional group(s) on a straight chain hydrocarbon backbone, when given the correct IUPAC name for the compound (3.1xx)	<ul style="list-style-type: none"> ◆ making perfume ◆ wine production ◆ nuclear magnetic resonance spectroscopy (NMR), (MRI) ◆ dyes ◆ cosmetics ◆ odors (esters)
3.1ii	VII.4	Isomers of organic compounds have the same molecular formula, but different structures and properties.	Above Core – R: identify, draw and name isomers of organic compounds.	<ul style="list-style-type: none"> ◆ types, varieties, uses of organic compounds ◆ organic isomers
5.2e	VII.5	In a multiple covalent bond, more than one pair of electrons are shared between two atoms. Unsaturated organic compounds contain at least one double or triple bond.		<ul style="list-style-type: none"> ◆ saturated vs. unsaturated compounds—health connections
3.2c	VII.6	Types of organic reactions include: addition, substitution, polymerization, esterification, fermentation, saponification, and combustion.	identify types of organic reactions (3.2iv) determine a missing reactant or product in a balanced equation (3.2iii)	<ul style="list-style-type: none"> ◆ saponification—making soap ◆ polymerization- formation of starches ◆ fermentation—alcohol production ◆ combustion of fossil fuels ◆ cellular respiration

KEY	LINK TO APPENDIX A	MAJOR UNDERSTANDINGS	SKILLS The student should be able to:	REAL-WORLD CONNECTIONS
VIII. Oxidation-Reduction				
3.2d	VIII.1	An oxidation-reduction (redox) reaction involves transfer of electrons.	determine a missing reactant or product in a balanced equation (3.2iii)	<ul style="list-style-type: none"> ◆ electrochemical cells ◆ corrosion ◆ electrolysis ◆ photography ◆ rusting
3.2e	VIII.2	Reduction is the gain of electrons.		<ul style="list-style-type: none"> ◆ smelting ◆ leaching (refining of gold) ◆ thermite reactions (reduction of metal oxides, e.g., aluminum)
3.2f	VIII.3	A half-reaction can be written to represent reduction.	write and balance half-reactions for oxidation and reduction of free elements and their monatomic ions (3.2vi)	
3.2g	VIII.4	Oxidation is the loss of electrons.	Above Core – H: Balance complex redox reactions in acid / base / neutral solutions	◆ recovery of active non-metals (I ₂)
3.2h	VIII.5	A half-reaction can be written to represent oxidation.		
3.3b	VIII.6	In a redox reaction the number of electrons lost is equal to the number of electrons gained.	Above Core – R: balance complex reactions using the half-reaction method	
3.2i	VIII.7	Oxidation numbers (states) can be assigned to atoms and ions. Changes in oxidation numbers indicate that oxidation and reduction have occurred.	Above Core – R: assign oxidation #'s. identify oxidation and reduction identify oxidizing agent and reducing agent	

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3.2j	VIII.8	An electrochemical cell can be either voltaic or electrolytic. In an electrochemical cell, oxidation occurs at the anode and reduction at the cathode.	<p>compare and contrast voltaic and electrolytic cells (3.2ix)</p> <p>Above Core – R: calculate cell potential at standard conditions</p> <p>Above Core – H: calculate cell potential at standard conditions and non-standard conditions using the Nernst equation $E = E^{\circ} - 0.0561/n \log Q$</p> <p>Faraday's law relating coulombs to moles of electrons $I = q/t$</p>	<p>♦ patina (copper—Statue of Liberty)</p> <p>Above Core – R: Chemistry of Corrosion</p> <p>Voltage of household batteries</p>
3.2k	VIII.9	A voltaic cell spontaneously converts chemical energy to electrical energy.	<p>identify and label the parts of a voltaic cell (cathode, anode, salt bridge) and direction of electron flow, given the reaction equation (3.2vii)</p> <p>use an activity series to determine whether a redox reaction is spontaneous (3.2x)</p> <p>Above Core – R: identify the purpose of a salt bridge or porous cup</p>	<p>Above Core – H: Dry Cell Automobile battery Rechargeable Cadmium and Lithium Batteries</p>
3.2l	VIII.10	An electrolytic cell requires electrical energy to produce chemical change. This process is known as electrolysis.	<p>identify and label the parts of an electrolytic cell (anode, cathode) and direction of electron flow, given the reaction equation (3.2viii)</p> <p>Above Core – R: analyze the electrolysis process for compounds such as water and/or NaCl(l)</p>	<p>♦ metallurgy of iron and steel</p> <p>♦ electroplating</p> <p>Above Core – H: Down Cell for the industrial production of Na metal and chlorine gas</p>