

DeRuyter Central School District

Physical Science/Chemistry

Grade 11

69 Benchmarks

►Standard 8: Understands the structure and properties of matter

Unit I: Measurement

- CH11.1.1 Understands how to recognize and convert various scales of measurement
- CH11.1.2 Knows how to report answers to calculations using the correct number of significant digits
- CH11.1.3 Knows how to distinguish between accuracy and precision
- CH11.1.3 Understands how to organize, graph and analyze data gathered from laboratory activities or other sources

Unit II: Matter and Energy

- CH11.2.1 Understands that there is a conservation of mass, energy and charge in all reactions.
- CH11.2.2 Understands that a compound is a pure substance composed of two or more different elements that are chemically combined in a fixed proportion.
 - Can be broken down by chemical means
 - Can be represented by a specific chemical formula
- CH11.2.3 Understand that chemical reactions either release or consume energy
 - Endothermic reactions
 - Exothermic reactions
- CH11.2.4 Understands that matter is classified as a pure substance or as a mixture of substances.
 - A pure substance has constant chemical composition and properties throughout a given sample (element and compound).
 - Elements are pure substances that are composed of atoms that have the same atomic number.
 - Elements cannot be broken down by a chemical change.
 - Mixtures have 2 or more substances that can be separated by physical means (filtration, distillation, chromatography, evaporation).
 - Mixtures can be either homogeneous or heterogeneous.
 - The three states of matter are solids, liquid, and gas.
 - Use particle model/diagrams to differentiate among elements, compounds, and mixtures.

CH112.5 Knows that energy can exist in different forms, such as chemical, electrical, electromagnetic, thermal, mechanical and nuclear.

- Heat is a transfer of 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
- Temperature is a measurement of average kinetic energy.
- Convert temperatures in Celsius degrees to Kelvins
- Calculate the energy change in a physical or chemical reaction (calorimetry).

CH11.2.6 Understands that a physical change results in the rearrangement of existing particles in a substance and a chemical change results in the formation of different substance with changed properties.

UNIT III: Atomic Structure

CH113.1 Knows the structure of an atom.

- The modern model of the atom has evolved over a period of time through the work of many scientists.
- Each atom has a nucleus, with an overall positive charge, surrounded by negatively charged electrons. The number of protons is equal to the number of electrons in a neutral atom.
- Negative electrons occupy most of the space in an atom
- In the Wave Mechanical Model electrons are located in orbitals.
- Neutrons (with no charge) and positively charged protons make up the nucleus of the atom
- Protons and neutrons are almost two thousand times heavier than an electron with approximately one atomic mass unit each.
- The electric force between the nucleus and the electrons holds the atoms together
- The protons and neutrons in an atom (mass number) identifies an isotope.
- Calculate the mass of an atom, the number of neutrons, or the number of protons, given the other two values

CH11.3.2 Understands that atoms of an element that contain the same number of protons but a different number of neutrons are called isotopes of that element.

- The average atomic mass of an element is the weighted average of the masses of its naturally occurring isotopes
- Given an atomic mass, determine the most abundant isotope
- Calculate the atomic mass of an element, given the masses and ratios of naturally occurring isotopes

UNIT IV: Nuclear Chemistry

CH11.4.1 Understands and interprets isotopic notations such as ^{14}C , carbon-14, C-14.

CH11.4.2 Knows that nuclear reactions convert a fraction of the mass of interacting particles into energy and release much greater amounts of energy than atomic interactions

- Determine decay mode and write nuclear equations showing alpha, beta, positron, and/or gamma radiation from the nucleus of an unstable isotope
- Identify the specific decay mode and half-life for a radioisotope based on reference table data
- Calculate the initial amount, the fraction remaining, or the half life of a radioactive isotope, given two of the three variables
- Nuclear reactions include natural and artificial transmutations, fission, and fusion
- There are benefits and risks associated with fission and fusion reactions

CH11.4.2 Knows that most elements have two or more isotopes

- Atoms of an element that contain the same number of protons but a different number of neutrons are called isotopes
- The average atomic mass of an element is the weighted average of the masses of its naturally occurring isotopes.
- Stability of an isotope is based on the ratio of neutrons and protons in its nucleus. Although most nuclei are stable, some are unstable and spontaneous decay, emitting radiation.
- Spontaneous decay involves the release of energy with the emission of either alpha, beta, or gamma particles. These emissions differ in mass, charge, ionizing power, and penetrating power.

CH11.4.3 Understands the uses and risks associated with nuclear reactions:

- Radioactive dating (C-14, U-238 series)
- Medical uses (Co-60, I-131)
- Long term storage
- Nuclear accidents and proliferation

UNIT V : Electron Configurations

CH115.1 Understands the various energy states with respect to electrons configurations

- Each electron has its own distinct amount of energy.
- Ground state is a lowest energy electron placement and excited state electron configuration comes from added energy to an electron (2—8-2 vs. 2-7-3)
- Release of energy when an excited state electron returns to a lower energy state
- Element identification using bright-line spectrum

CH115.2 Knows how the electron configuration of atoms governs the chemical properties of an element as atoms interact with one another by transferring or sharing the outermost electrons

- The outermost electrons are called valence electrons
- chemical properties are functions of valence electron configurations

- Lewis dot diagram of an atom utilizes valence electrons, non-valence electrons and kernel.
- In the wave-mechanical model, the electrons are in orbitals, which are defined as the regions of the most probably electron location (ground state)

UNIT VI : Periodic Table

- CH11.6.1 Understands how elements are arranged in the periodic table and how this arrangement shows repeating patterns among elements with similar properties
- The placement or location of elements 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
 - Mendeleev developed the first Periodic Table based on atomic mass
 - Today, the modern table is based on atomic number

- CH11.6.2 Understands how to classify various elements based on their properties
- Elements can be differentiated by their physical properties and chemical properties.
 - Elements can be classified by their properties and located on the Periodic Table as metals, nonmetals, metalloids, and noble gases
 - Predict the placement of an unknown element based on its properties
 - For groups 1, 2 and 13-18 on the Periodic Table, elements with the same number of valence electrons (He is an exception) are located in the same group and have similar chemical properties.
 - Describe the physical states of the elements at STP
 - Diatomic gases
 - Liquids (Hg, Br₂)
 - Some elements can exist in two or more forms in the same phase. These forms differ in their molecular or crystal structure and hence in their properties.
 - Groups 1, 2, 17, 18 are known as alkali metals, alkaline earth metals, halogens, and noble gases respectively.

- CH11.6.3 Knows the periodic trends in groups and periods.
- Explain periodic trends within groups and periods relative to atomic radius, ionic radius, electronegativity, first ionization energy, and metallic/nonmetallic properties.

UNIT VII: Bonding

- CH11.7.1 Knows that physical properties of a compound are determined by its molecular structure
- constituent atoms
 - distances and angles between them
 - interactions between these molecules

- CH11.7.2 Knows that the number of electrons in an atom determines whether the atom is electrically neutral or an ion

- electrically neutral atoms contain equal numbers of protons and neutrons
- positively charged atoms have lost 1 or more electrons
- negatively charged atoms have gained 1 or more electron

CH11.7.3. Knows that atoms attain a stable valence electron configuration (octet) by bonding with other atoms. Noble gases have stable valence electron configurations and tend not to bond.

CH11.7. Understands how electron dot diagrams (Lewis structures) can represent the valence electron arrangement in elements, compounds, and ions

- Demonstrate bonding concepts using Lewis dot structures representing valence electrons: transferred (ionic bonding), shared (covalent bonding); in a stable octet

CH11.7.5 Knows that chemical bonds are formed between valence electrons.

- Ionic bonds
- Covalent bonds
- Metallic bonds
- Multiple covalent bonds

CH11.7.6 Understands the energy changes that take place in bonding:

- Energy is given off when bonds form
- Energy is required to break bonds

CH11.7.7 Knows that molecular polarity can be determined by the shape of the molecule and the distribution of charge.

- Symmetrical (nonpolar)
- Asymmetrical (polar)

CH11.7.8 Knows that valence electrons can be transferred to other elements and the radius increases or decreases accordingly.

- Negative ions
- Positive ions
- Formation of stable valence configurations

CH11.7.9 Knows that physical properties of substances can be explained in terms of chemical bonds and intermolecular forces.

- Physical properties (conductivity, solubility, hardness, etc.)
- Dipole-dipole
- Hydrogen bonds
- Van der Waals /London dispersion forces

CH11.7.10 Understands the concept of electronegativity and how strongly an atom of an element attracts electrons in a chemical bond.

- Degree of polarity

CH11.7.11 Knows that metals react with non-metals to form ionic compounds. Nonmetals react with other non-metals to form covalent compounds. Ionic compounds containing polyatomic ions have both ionic and covalent bonding.

UNIT VIII; Formula Writing

CH11.8.1 Understands the complete mole concept and ways in which it can be used

- 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.
- Relationship between molar mass and molar volume at STP
- Relationship between molar mass, molar volume, and Avogadro's number (Avogadro's hypothesis).

CH11.8.2 Understands the three types of chemical formulas

- Empirical (Knows that the empirical formula is the simplest whole number ratio of atoms of the elements in a compound.)
- Structural formula
- Molecular formula

CH11.8.3 Understands that the percent composition of each element in a compound can be calculated mathematically.

UNIT IX: Stoichiometry of Equations

CH11.9.1 Knows the different types of chemical formulas for chemical reactions.

- Balanced equations
- Synthesis, decomposition, single and double replacement equations
- Reactants versus products

CH11.9.2 Understand that there is a conservation of mass and energy in all reactions.

CH11.9.3 Knows the role of coefficients in balanced formula equations.

- Mole ratios in a balanced formula
- Mole-mole stoichiometry problems
- Mass of substances vs. number of moles of substances

UNIT X: Solids & Liquids

CH11.10.1 Understands the concepts of kinetic and potential energy that can be used to explain physical processes that include : fusion (melting), solidification (freezing), vaporization (boiling, evaporation), condensation, sublimation, and deposition.

CH11.10.2 Understands how to use a simple particle model to differentiate among properties of a solid, a liquid, and a gas. Knows how to distinguish between heat energy and temperature in terms of molecular motion and amount of matter.

CH11.10.3 Knows how to qualitatively interpret heating/cooling curves in terms of changes in kinetic and potential energy, heat of vaporization, heat of fusion, and phase changes: Explain phase changes in terms of changes in energy and intermolecular distance

UNIT XI: Gases

- CH11.11.1 Understands that the concept of an ideal gas is a model to explain the behavior of all gases. A real gas is most like an ideal gas when the real gas is at low pressure and high temperature. Understands the Kinetic Molecular Theory for ideal gases which states that all gas particles:
- Are in random, constant straight-line motion.
 - Are separated by great distances relative to their size; the volume of the gas particles is considered negligible.
 - Have no attractive forces between them.
 - Have collisions that may result in the transfer of energy between gas particles.
- Ch11.11.2 Knows that equal volumes of different gases under the same temperature and pressure contain equal number of particles (Avogadro's Hypothesis)
- CH11.11.3 Understands how to use the gas laws to predict the behavior of gases
- Pressure vs volume (Boyle)
 - Volume vs temperature (Charles)
 - Volume, temperature and pressure (Combined)
 - Total pressure equals the sum of the partial pressures (Dalton)

UNIT XII: Solutions

- CH11.12.1 Knows that there are differences in physical properties that allow physical separation of the components in the mixture.
- Density
 - Particle size
 - Boiling point
 - Freezing point
 - Molecular polarity
- CH11.12.2 Understands that a solution is a mixture of a solute in a solvent.
- Concentrations expressed as molarity (M), percent by volume, percent by mass or parts per million (ppm).
 - Knows how to interpret solubility curves to determine whether a solution is saturated, unsaturated, or supersaturated.
 - Able to use solubility guidelines to predict solubility of solutes in aqueous solutions.

CH11.12.3 Knows that the concentration of non-volatile solute particles affects the properties of the solvent:

- Freezing point depression
- Boiling point elevation
- Vapor pressure elevation

UNIT XIII: Acids and Bases

CH11.13.1 Understands that behavior of many acids and bases can be explained by the Arrhenius theory.

- Arrhenius acids and bases are electrolytes
- Electrolytes are substances which, when dissolved in water, form a solution capable of conducting an electric current
- The ability of a solution to conduct an electric current depends on the concentration of ions
- Given properties, identify substances as Arrhenius acids or Arrhenius bases.

CH11.13.2 Understands that Arrhenius acids yield H^+ (aq), hydrogen ions, as the only positive ions in solution.

- The hydrogen ion may also be written as H_3O^+ (aq), the hydronium ion.

CH11.13.3 Understands that Arrhenius bases yield OH^- (aq), hydroxide ions, as the only negative ions in solution

CH11.13.4 Knows that in the process of neutralization, an Arrhenius acid and an Arrhenius base react to form a salt and water.

- Titration is a laboratory process in which a volume of solution of known concentration is used to determine the concentration of another solution.
- Write simple neutralization reactions when given reactants
- Calculate the concentration or volume of a solution using titration data

CH11.13.5 Understands that there are alternate acid-base theories.

- Bronsted-Lowry Theory states that an acid is an H^+ donor and a base is an H^+ acceptor.

Ch11.13.6 Understands that the acidity or alkalinity of a solution can be measured by its pH value.

- The relative level of acidity or alkalinity of a solution can be shown by using indicators
- On the pH scale, each decrease of one unit of pH represents a tenfold increase in hydronium ion concentration.
- Identify solutions as acid, base, or neutral based upon the pH.

UNIT XIV: Kinetics, Equilibrium and Thermodynamics

Ch11.14.1 Knows that chemical reactions can take place at vastly different rates

- CH11.14.2 Understands that collision theory states that a reaction is most likely to occur if reactant particles collide with the proper energy and orientation. The rate of a chemical reaction depends on several factors: temperature, concentration, nature of reactants, surface area and the presence of a catalyst
- CH11.14.3 Knows how to identify examples of physical equilibria as solution equilibrium and phase equilibrium, including the concept that a saturated solution is at equilibrium
- CH11.14.4 Understands how to distinguish between endothermic and exothermic reactions using energy terms in a reaction equation, change in enthalpy, potential energy diagrams or experimental data
- Read and interpret potential energy diagrams: PE reactants, PE products, activation energy, and heat of reaction
 - Show the effect of adding a catalyst to a reaction on a PE diagram
- CH11.14.5 Knows that chemical reactions can be accelerated by catalyst (metallic surfaces, enzymes)
- CH11.14.6 Knows how to qualitatively describe the effect of stress (concentration, pressure, and temperature) on equilibrium using LeChatelier's principle.
- CH11.14.7 Knows that entropy is a measure of the randomness of a system. A system with greater disorder has greater entropy
Systems in nature tend to undergo changes toward lower energy and higher entropy
Compare the entropy of phases of matter

UNIT XV: Redox and Electrochemistry

- CH11.15.1 Knows that an oxidation-reduction (redox) reaction involves the transfer of electrons.
- Reduction is the gain of electrons
 - Oxidation is the loss of electrons
 - Half-reactions can be written to represent reduction and oxidation
 - In a redox reaction the number of electrons lost is equal to the number of electrons gained
- CH11.15.2 Understands that oxidation numbers (states) can be assigned to atoms and ions. Changes in oxidation numbers indicate that oxidation and reduction have occurred.
- Oxidation states indicate the number of electrons that have been gained or lost by an atom

- Predict the oxidation states of atoms in various compounds/ions
- CH11.15.3 Understands that an electrochemical cell can be either voltaic or electrolytic. In an electrochemical cell, oxidation occurs at the anode and reduction occurs at the cathode.
- A voltaic cell spontaneously converts chemical energy to electrical energy.
 - Identify and label that parts of a voltaic cell (cathode, anode, salt bridge) and direction of electron flow given the reaction equation
 - Use an activity series to determine whether a redox reaction is spontaneous
 - Compare and contrast voltaic and electrolytic cells
 - An electrolytic cell requires electrical energy to produce chemical change. This process is known as electrolysis.

UNIT XVI: Organic

- CH11.16.1 Understands that 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
 - Organic compounds are classified based on their structural formulas
- CH11.16.2. Knows that hydrocarbons are compounds that contain only carbon and hydrogen and are categorized into homologous series:
- 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 10 carbon atoms
- CH11.16.3 Understands that functional groups impart distinctive physical and chemical properties to organic compounds
- Use Table R to identify the structural formulas for Organic acids, alcohols, esters, aldehydes, ketones, ethers, halides, amines, amides, and amino acids.
 - Draw a structural formula with the functional group(s) on a straight chain hydrocarbon backbone, when given the correct IUPAC name for the compound
- CH11.16.4 Knows that isomers of organic compounds have the same molecular formula, but different structures and properties.
- CH11.16.5 Understands that 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

VH11.16.6

Knows that types of organic reactions include: addition, substitution, polymerization, esterification, fermentation, saponification, and combustion.

- Identify types of organic reactions
- Determine a missing reactant or product in a balanced equation