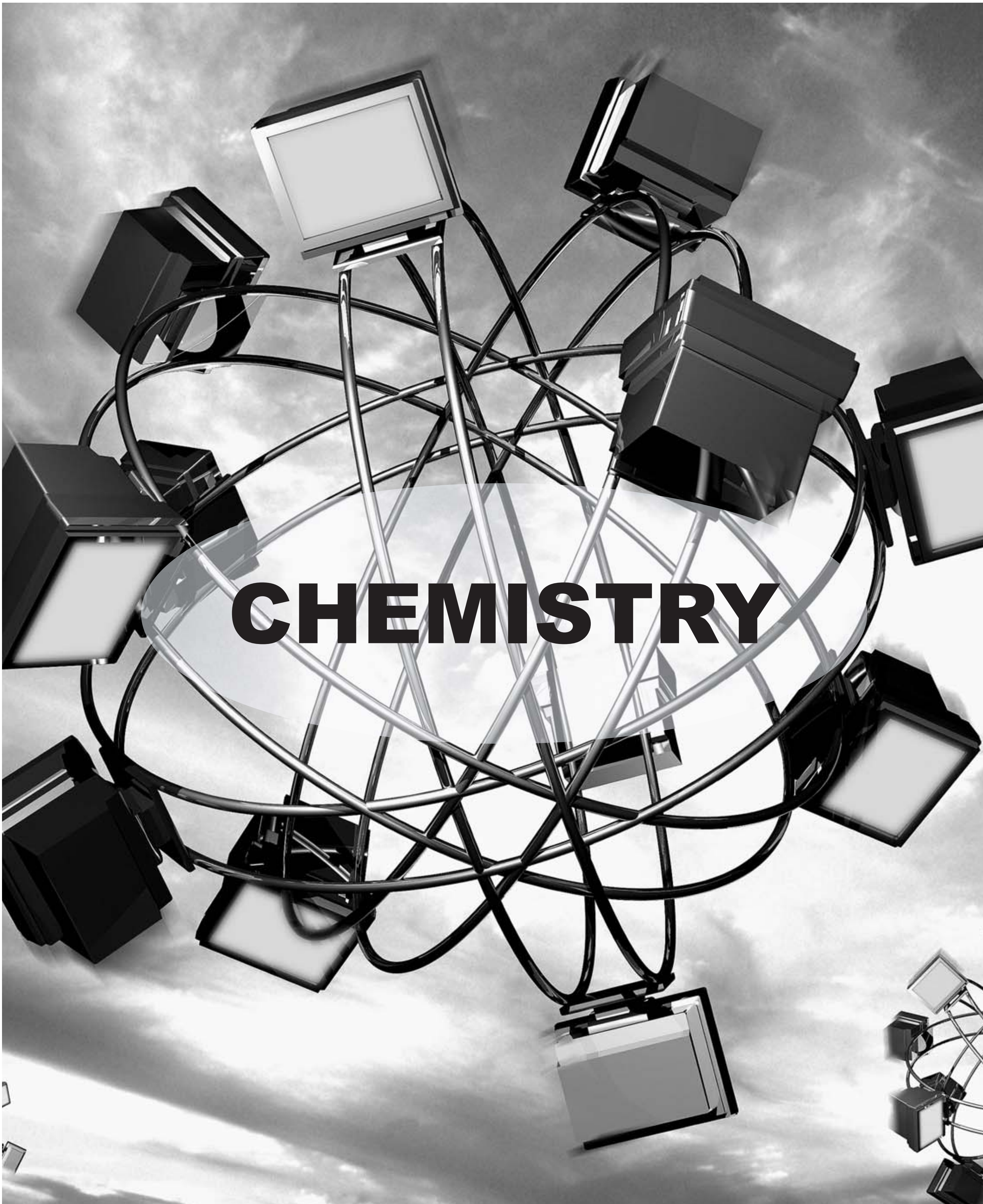
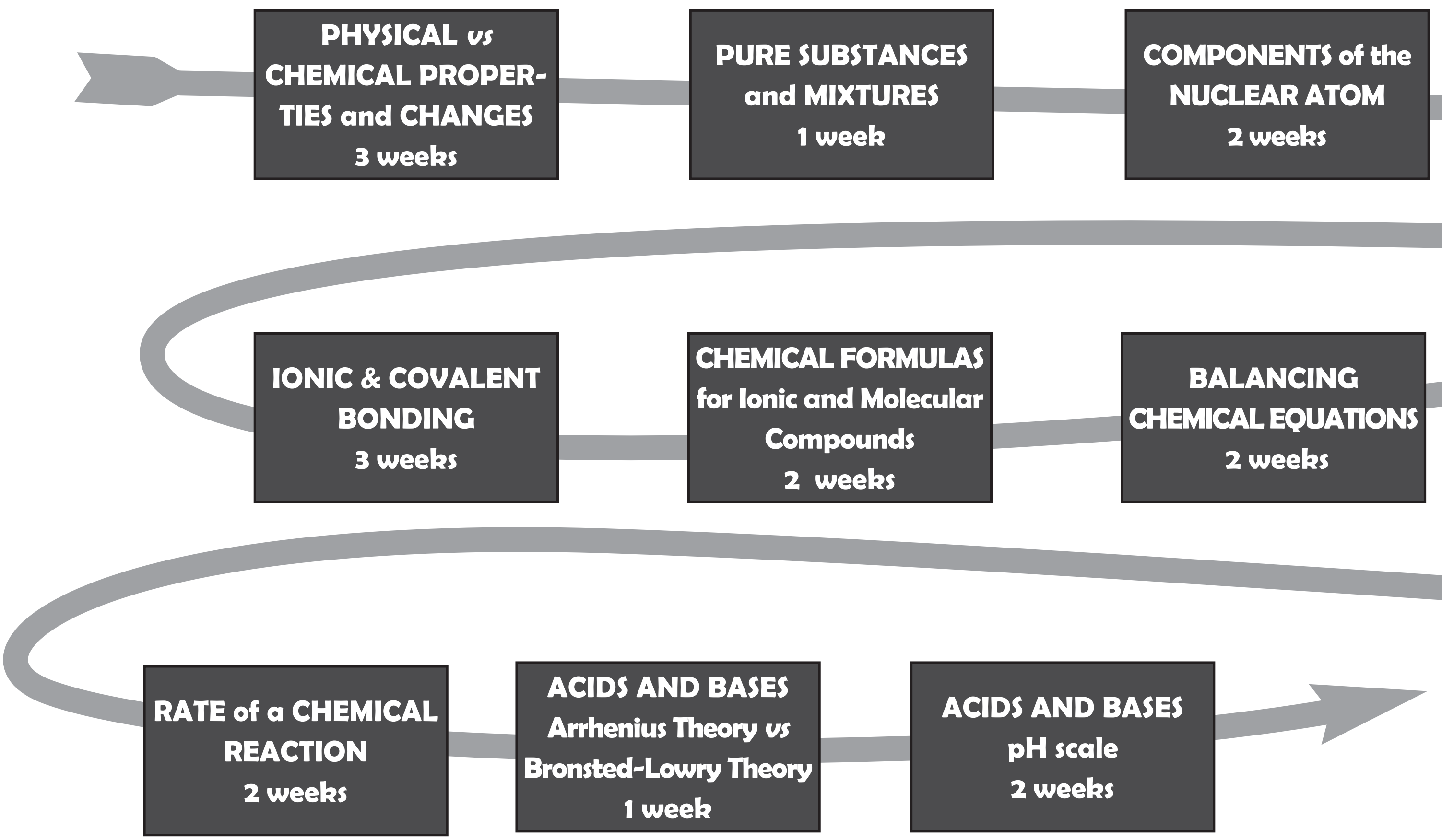

CHEMISTRY

SCIENCE INSTRUCTION IN DYS

Sequence of Topics in Chemistry

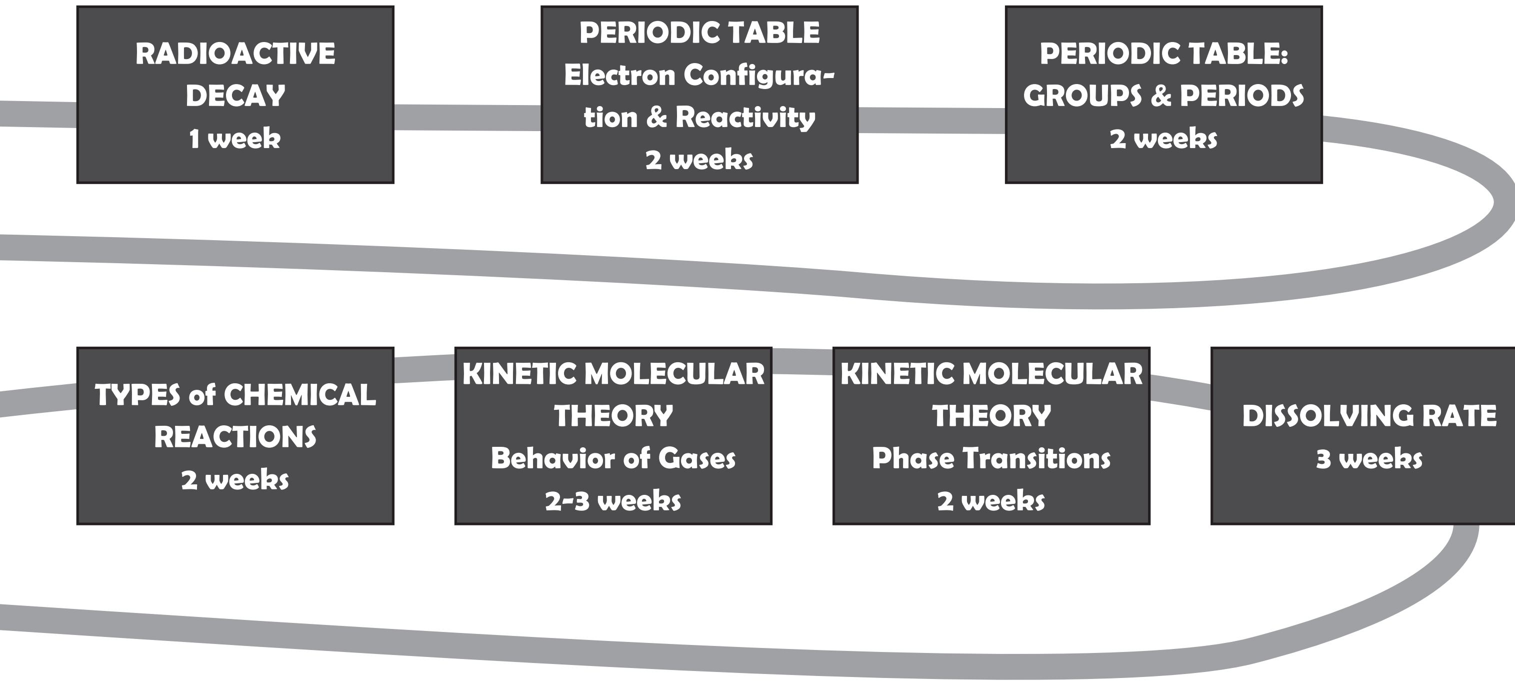


Addressing All Strands

In all DYS settings, the primary focus of science instruction is Biology, which shall be taught through a combination of mini-units, Problems of the Day, and other lessons and instructional strategies, as appropriate to each type of setting. Additionally, SCIENTIFIC INQUIRY SKILLS are essential to good teaching and should be integrated into *all* science topics and strands.

In instances where students have completed the Biology strand in their previous school, and/or when students were engaged in learning other strands in their previous school, students will require instruction in CHEMISTRY or Physics. A full scope and sequence, as well as curriculum exemplars in Biology, Chemistry, and Introductory Physics, is included in this Instructional Guide.

The graphic below is repeated throughout this section to suggest sequencing and an approach to teaching each Strand of the Science Curriculum Framework. Allocation of time for each topic should be flexible in response to holidays, periods of MCAS testing, and other factors.



LEARNING OBJECTIVES

For each strand and emphasized standard, an extended grid outlines what students should KNOW, UNDERSTAND, and be able to DO to demonstrate progress toward specific learning objectives. Primary resources are indicated, and because specialized vocabulary is vital to science learning, important new terminology is highlighted for emphasis.

LESSON PLANNING

The extended KNOW-UNDERSTAND-DO grids are carefully designed to help teachers in all DYS settings develop rigorously standards-based teaching activities. The order of topics in each strand (above) is *suggested,* but it is not *required*; the needs of the students and the type of setting will also affect how teachers proceed through each strand.

EXEMPLARS

A set of exemplary curricular materials is provided in this guide. Each exemplar (Mini-Unit, Lesson, and Problem of the Day) is fully elaborated, offering DYS teachers strong models to use in developing and sharing their own teaching materials. A blank template for developing lessons is provided in the Biology section, following the Genetics Mini-Unit and the demonstration lesson. (Look for additional materials to complement this guide on CD.)

WHAT CHEMISTRY SHOULD STUDENTS KNOW?

Key topics in Chemistry	RELATED STANDARDS
PROPERTIES OF MATTER	**C 1.1** Identify and explain physical properties (e.g., density, melting point, boiling point, conductivity, malleability) and chemical properties (e.g., the ability to form new substances). Distinguish between chemical and physical changes. **PS 2, 9, 10**
PROPERTIES OF MATTER	**C 1.2** Explain the difference between pure substances (elements and compounds) and mixtures. Differentiate between heterogeneous and homogeneous mixtures. **PS 5, 6, 8**

HOW DO WE KNOW THAT THEY KNOW IT?

Learning Objectives

STUDENTS SHOULD KNOW	UNDERSTAND (Essential Questions)	AND BE ABLE TO DO
▸ That **physical properties** are characteristics that do not change the substance ▸ That **chemical properties** are characteristics that show how a substance could change into something different ▸ Examples of physical and chemical properties ▸ That **physical changes** are changes in the substance related to temperature, shape, size, state of matter, etc. ▸ That **chemical changes** are changes in a substance that result in the formation of a totally new substance	▸ That physical changes do not change what the substance is ▸ That the particles in matter are constantly in motion, but they have different amounts of motion and energy in each of the three states of matter—solid, liquid, gas (refer to Standard C 1.3) ▸ Chemical changes do not create something new but instead change the original substance into a different substance or substances	▸ Determine the identity of or physical property of an unknown object/substance when given samples of data (tables, charts, and/or graphs) ▸ Interpret the density of unknown objects/substances based on comparison within a density column (a density column is composed of layers of solutions with differing densities, with the densest solution at the bottom) ▸ Describe characteristics of phase changes and the states of matter involved (evaporation, melting, etc.) ▸ Create a 4-1 frame cartoon strip explaining the difference between chemical and physical changes
▸ That **elements** are composed of only one kind of particle—**atom** ▸ That **compounds** are composed of only one kind of particle—**molecule** ▸ That elements undergo chemical changes, combining to make different compounds ▸ That **mixtures** are composed of different particles from different substances ▸ The difference between **heterogeneous mixtures** and **homogeneous mixtures**	▸ That the formation of compounds occurs when the atoms of two or more elements combine by undergoing a chemical change ▸ Elements and compounds cannot be physically separated ▸ Mixtures can be separated back into two or more different and often simpler substances	▸ Identify examples of pure substances (elements and compounds) and mixtures ▸ Describe similarities and differences between the following using a Venn diagram: • Elements vs. compounds • Pure substances and mixtures ▸ Compare and contrast homogeneous and heterogeneous mixtures; identify and provide examples of each ▸ Create homogeneous and heterogeneous mixtures using household items

WHAT CHEMISTRY SHOULD STUDENTS KNOW?

Key topics in Chemistry	RELATED STANDARDS
ATOMIC STRUCTURE AND NUCLEAR CHEMISTRY Connection: See Biology: Cycles of Life, Chapter 2, Basic Chemistry, subsection: *Atoms and Molecules*	**C 2.2** Describe Rutherford's "gold foil" experiment that led to the discovery of the nuclear atom. Identify the major components (protons, neutrons, and electrons) of the nuclear atom and explain how they interact. **PS 6**

Learning Objectives

STUDENTS SHOULD KNOW	UNDERSTAND (Essential Questions)	AND BE ABLE TO DO
‣ That atoms are made of three basic parts, or **subatomic particles: protons, neutrons**, and **electrons** ‣ That protons have a positive electric charge, and electrons have a negative electric charge; neutrons have no electric charge but play an important role in the atom ‣ That protons and neutrons are found in the **nucleus**, or the center, of an atom: All atoms of the same element have the same number of protons ‣ That electrons, which are much smaller in size and mass, move around the nucleus in **energy levels** or **orbitals**	‣ When a "neutral" atom is not bonded (connected) with another atom, it has the same number of protons and electrons: When there are more or less electrons than protons, the charges are not balanced and the atom is called an **ion** ‣ That most of the atom's mass is located in the nucleus. ‣ That neutrons play an important role in the atom. Changes in the number of neutrons results in the formation of **isotopes**	‣ Construct a model of an atom and its subatomic particles: protons, neutrons, and electrons, paying attention to placement and differences in size ‣ Argue which subatomic particle the student thinks might be the most important by comparing the properties of each (i.e., electric charge, mass (in atomic mass units (amu), and location) ‣ Explain where most of the atom's mass is located and why ‣ Identify when an atom is "neutral" given the number of protons and electrons present in the atom

WHAT CHEMISTRY SHOULD STUDENTS KNOW?

Key topics in Chemistry	RELATED STANDARDS
ATOMIC STRUCTURE AND NUCLEAR CHEMISTRY	**C 2.5** Identify the three main types of radioactive decay (alpha, beta, and gamma) and compare their properties (composition, mass, charge, and penetrating power)

Learning Objectives

STUDENTS SHOULD KNOW	UNDERSTAND (Essential Questions)	AND BE ABLE TO DO
‣ That isotopes with too many or too few neutrons are unstable and thus radioactive ‣ Release of radiation is radioactivity. This occurs when an unstable nucleus begins to break down, a process called **radioactive decay** ‣ The three basic types of radioactive decay: **alpha decay**, beta decay, and gamma decay. ‣ Both alpha and beta decay changes the original isotope into a different element through a process called **transmutation** ‣ How the **half-life** of an element is related to radioactive decay (refer to Standard C 2.6)	‣ That radioactive decay begins with unstable elements and results in more stable products ‣ Radioactive decay is the loss of energy through radiation in the form of particles or electromagnetic waves ‣ Radioactive decay is used in many helpful ways (i.e., smoke detectors and medical treatments)	‣ Compare and contrast the different types of radioactive decay and their properties, being sure to include: • Differences in what is emitted during the process, • The process involved, • The changes that the original isotope undergoes, and • Examples of each ‣ Create a public awareness brochure describing a positive or negative form of radiation. ‣ Describe natural forms of nuclear reactions such as radioactive decay in contrast to other types such as nuclear bombardment **(nuclear fission** and **nuclear fusion**) (refer to Standard C 2.7)

WHAT CHEMISTRY SHOULD STUDENTS KNOW?

Key topics in Chemistry	RELATED STANDARDS
PERIODICITY	**C 3.1** Explain the relationship of an element's position on the periodic table to its atomic number. Identify families (groups) and periods on the periodic table.

Learning Objectives

STUDENTS SHOULD KNOW	UNDERSTAND (Essential Questions)	AND BE ABLE TO DO
‣ That elements located near the top of the periodic table have smaller **atomic numbers** than those located at the bottom ‣ That elements on the left side of each row on the periodic table have smaller atomic numbers than the rest of the elements in the same row ‣ That the horizontal rows on the periodic table are called **periods** ‣ That the vertical columns on the periodic table are called **families** or **groups** ‣ That an element's position in the periodic table determines which class of elements it is in: metals, nonmetals, or metalloids (refer to Standard C 3.2)	‣ That no two elements have the same number of protons, and thus, no two elements have the same atomic number ‣ Elements with greater atomic numbers often have greater atomic masses ‣ Elements in the same family often have similar physical and chemical properties	‣ Construct a periodic table to show patterns of elements within the same rows and/or columns ‣ Based on an element's position on the periodic table, determine if it is a metal or nonmetal (refer to Standard C 3.2) ‣ Describe similarities and differences of one element in relation to other elements ‣ Create "family books" describing each member (element) found in any given family (or column) on the periodic table

Key topics in Chemistry	RELATED STANDARDS
PERIODICITY	**C 3.3** Relate the position of an element on the periodic table to its electron configuration and compare its reactivity to the reactivity of other elements in the table. **PS 5**

Learning Objectives

STUDENTS SHOULD KNOW	UNDERSTAND (Essential Questions)	AND BE ABLE TO DO
▸ That the atomic number (or number of protons) determines the total number of electrons. Each energy level can only hold a set number of electrons ▸ The electron configurations for the first twenty elements of the periodic table (refer to Standard C 2.4) ▸ That electrons, especially valence electrons, of an atom play a crucial role in an element's reactivity (how it bonds or connects to atoms of other elements): • Based on the number of valence electrons, atoms can gain or lose electrons forming anions or cations, respectively	▸ That an element's position on the periodic table has a strong relationship to its electron configuration and its reactivity to other elements ▸ That elements in the same family have the same number of valence electrons and thus similar reactivity ▸ That there are patterns in the periodic table related to the size of atoms and ions, ionization energy, and electronegativity of different elements (refer to Standard C 3.4)	▸ Based on the electron configuration of an element, determine its most likely position on the periodic table ▸ Identify elements with high electronegativity ▸ Explain the role of electrons in chemical reactions by describing the process by which two atoms bond ▸ Identify anions or cations when represented by symbol only and describe their reactivity—for example, $^{16}O^{2-}$ or $^{7}Li^{1+}$ ▸ Investigate different types of common chemical reactions between elements, and be able to explain why these elements combin based on the electron configuration of their atoms

WHAT CHEMISTRY SHOULD STUDENTS KNOW?

Key topics in Chemistry	RELATED STANDARDS
CHEMICAL BONDING Connection: See Biology: Cycles of Life, Chapter 2, Basic Chemistry, subsections: *Chemical Formulas* and *Bonding Patterns*	**C 4.1** Explain how atoms combine to form compounds through both ionic and covalent bonding. Predict chemical formulas based on the number of valence electrons. **PS 5, 6**

Learning Objectives

STUDENTS SHOULD KNOW

- The difference between **monatomic**, **diatomic**, and **polyatomic** atoms/molecules
- That atoms of different elements form **bonds**, thus combining to form compounds
- That **ionic bonds** form when atoms combine by losing or gaining valence electrons. This process occurs between positive and negative ions of different elements
- That **covalent bonds** form when atoms of different elements share valence electrons

UNDERSTAND (Essential Questions)

- That the goal of both ionic and covalent bonding is to completely fill the last energy level, or orbital, of each bonding atom
- That an atom's electrons determine its reactivity, and thus, electrons play a very important role in chemical bonding
- That when atoms gain or lose electrons in ionic bonding, the radius of the atoms will increase or decrease respectively
- That chemical bonding between two or more elements forms compounds

AND BE ABLE TO DO

- Explain the role of electrons in a chemical reaction between atoms o different elements
- Describe what makes a covalent bond and what makes an ionic bonc
- Given a chemical formula, determine the shape and structure of a molecule (i.e., Lewis dot diagrams) (refer to Standard C 4.2)
- Predict the chemical formula for a compound (e.g., oxygen and beryllium form BeO)
- Draw representations of examples of covalent and ionic bonding between two or more atoms
- Identify examples of ionic and covalent bonding when given the chemical formula or a graphic representation

WHAT CHEMISTRY SHOULD STUDENTS KNOW?

Key topics in Chemistry	RELATED STANDARDS
CHEMICAL BONDING Connection: See Biology: Cycles of Life, Chapter 2, Basic Chemistry, subsection: *Chemical Formulas* and *Bonding Patterns*	**C 4.6** Name and write the chemical formulas for simple ionic and molecular compounds, including those that contain the polyatomic ions: ammonium, carbonate, hydroxide, nitrate, phosphate, and sulfate.
CHEMICAL REACTIONS AND STOICHIOMETRY	**C 5.1** Balance chemical equations by applying the laws of conservation of mass and constant composition (definite proportions). **PS 5, 6**

Learning Objectives

STUDENTS SHOULD KNOW	UNDERSTAND (Essential Questions)	AND BE ABLE TO DO
▸ Simple ionic and molecular compounds and their formulas such as, HCl (hydrochloric acid) or $CaCO_3$ (calcium chloride) ▸ The chemical formulas for the following: Ammonium NH_4 Carbonate CO_3 Hydroxide OH^{1-} Nitrate NO_3 Phosphate PO_4 Sulfate SO_4	▸ That the valence electrons of an atom will determine if it will form ionic or covalent bonds with other elements (tool: Lewis dot diagrams) ▸ That elements from one family on the periodic table will bond similarly to other elements from a different family. The ratio of atoms in the resulting molecule is always the same	▸ Determine the name of a compoun when given its molecular formula ▸ Hypothesize the number of valence electrons of one element when give the molecular formula for a polyatomic compound ▸ Compare and contrast the common polyatomic ions (cations vs. anions types of compounds they form, etc. ▸ Investigate different examples of compounds that include the common polyatomic ions such as ammonium or nitrate
▸ How chemical reactions demonstrate the **law of conservation of matter** and the **law of conservation of mass** ▸ That **coefficients** and **subscripts** are used to represent the total number of atoms of each element present in a chemical reaction	▸ That matter is neither created nor destroyed (what goes into a reaction must come out in some form or another!). ▸ What it means for a chemical equation to be "balanced" ▸ That coefficients represent the number of **moles** of each reactant and/or product in a chemical equation	For balancing chemical equations, the student will be able to: ▸ Identify the **reactants** and **products** in sample chemical equations ▸ Understand the meaning of the symbols used in an equation ($\rightarrow$, +, (*s*), (*l*), (*g*), (*aq*), coefficients, subscripts) ▸ Recognize when an equation is balanced, and solve unbalanced equations. ▸ Write a **balanced chemical equation** based on a written description of the reaction

WHAT CHEMISTRY SHOULD STUDENTS KNOW?

Key topics in Chemistry	RELATED STANDARDS
CHEMICAL REACTIONS AND STOICHIOMETRY Connection: See Biology: Cycles of Life, Chapter 3, Chemistry at the Cellular Level, subsection: *What are Organic Molecules?*	**C 5.2** Classify chemical reactions as synthesis (combination), decomposition, single displacement (replacement), double displacement, and combustion.
STATES OF MATTER, KINETIC MOLECULAR THEORY, AND THERMOCHEMISTRY	**C 6.1** Using the kinetic molecular theory, explain the behavior of gases and the relationship between pressure and volume (Boyle's law), volume and temperature (Charles's law), pressure and temperature (Gay-Lussac's law), and the number of particles in a gas sample (Avogadro's hypothesis). Use the combined gas law to determine changes in pressure, volume, and temperature.

Learning Objectives

STUDENTS SHOULD KNOW	UNDERSTAND (Essential Questions)	AND BE ABLE TO DO
▸ In general, what happens in a **synthesis** (or **combination**), **decomposition**, **single displacement** (or **single replacement**), and **double displacement** reaction: • For example, in a decomposition reaction, one large reactant will break down into two or more smaller products	▸ That chemical reactions are classified based on the type of reactants and products involved	▸ Recognize examples of each type o reaction: When elements are represented by symbols or letters: ($AB \rightarrow A + B$), and When elements are represented by their chemical abbreviations: ($2H_2O \rightarrow 2H_2 + O_2$)
▸ The **kinetic molecular theory** (a.k.a., the kinetic model) of gases ▸ The gas laws that describe the behavior of gases: **Boyle's law**, **Charles's Law**, and **Gay-Lussac's Law** ▸ **Avogadro's Hypothesis** and how it relates to gases ▸ The **combined gas law** ▸ How **pressure** (P), **volume** (V), **temperature** (T), **moles** (n) relate to each other and are measured based on each gas law	▸ That the gas laws apply to all gases, regardless of identity ▸ That changing one factor (pressure, volume, temperature, or moles) affects the others ▸ That the relationship between pressure, volume, temperature, and/or moles is represented by a mathematical formula for each gas law	▸ Develop a story from the perspective of the gas molecules describing what happens to them i a light bulb when turned on or off using the kinetic molecular theory. ▸ Describe the relationship between any of the four factors when illustrated in a graph ▸ Explain the relationship between the pressure, volume, temperature, and moles of gases in a demonstration when one factor changes; for example, if two containers of equal size are filled with equal amounts of different gases that have the same V, T, and P, then they must also have the same number of molecules (mole) ▸ Use the combined gas law to determine changes in pressure, volume, and temperature

WHAT CHEMISTRY SHOULD STUDENTS KNOW?

Key topics in Chemistry	RELATED STANDARDS
STATES OF MATTER, KINETIC MOLECULAR THEORY, AND THERMOCHEMISTRY	**C 6.3** Using the kinetic molecular theory, describe and contrast the properties of gases, liquids, and solids. Explain, at the molecular level, the behavior of matter as it undergoes phase transitions. **PS 15**
SOLUTIONS, RATES OF REACTION, AND EQUILIBRIUM	**C 7.3** Identify the factors that affect the rate of a chemical reaction (temperature, mixing, concentration, particle size, surface area, catalyst)

Learning Objectives

STUDENTS SHOULD KNOW	UNDERSTAND (Essential Questions)	AND BE ABLE TO DO
▸ That scientists have described **5 phases of matter** (solids, liquids, gases, plasma, and Bose-Einstein condensate) ▸ The three most common states of matter on earth, and the properties of each, based on the position and behavior of their particles (refer to Standard C 1.3) • **Solids** have a definite shape and volume • **Liquids** have a definite volume but not a definite shape, and • **Gases** have no definite shape or volume ▸ The relationship between temperature and the average kinetic energy of particles in matter ▸ That the tool to measure changes in average kinetic energy (particle speed) is the thermometer	▸ All matter is made up of particles (atoms, and/or molecules) held together by **attracting forces** ▸ That according to kinetic molecular theory, the particles that make up matter are always in motion ▸ That during phase changes, the temperature and the average kinetic energy of particles in matter increases as the particles begin to move further apart (solid → liquid → gas) ▸ Temperature is a measure of the **average speed of particles**.	▸ Create a graph representing the relationship between temperature and average kinetic energy ▸ Draw the molecules of water showing their position relative to each other during phase changes from ice (solid) to water (liquid) to vapor (gas). ▸ Explain the behavior of the molecules of water during each phase change in relation to temperature, average kinetic energy, and position ▸ Design a concept map showing different everyday examples of the kinetic molecular theory in action
▸ That solutes dissolve into solvents (refer to C 7.1) ▸ How changes in any of the following factors can increase or decrease the rate of dissolving: • temperature (average kinetic energy) • concentration of solute or solvent • surface area of solute • pressure • rate of mixing ▸ What happens at the molecular level for each factor	▸ That the process of dissolving occurs on the molecular level resulting in different degrees of solubility (also refer to Standard C 7.1) ▸ That water is not the only type of solvent	▸ Describe what happens when salt (solute) dissolves into water (solvent) (refer to Standard C 7.1) ▸ Explain how changes in temperature, concentration, surface area, pressure, and/or mixing can increase or decrease the rate of dissolving at the molecular level. ▸ Create a picture book using everyday examples, such as dissolving sugar into iced tea, to illustrate this standard and explain how various factors affect the rate of dissolving at the molecular level

WHAT CHEMISTRY SHOULD STUDENTS KNOW?

Key topics in Chemistry	RELATED STANDARDS
SOLUTIONS, RATES OF REACTION, AND EQUILIBRIUM Connection: See Biology: Cycles of Life, Chapter 6, ATP and Energy Cycles, subsection: *Enzymes and Energy Flow*	**C 7.5** Identify the factors that affect the rate of a chemical reaction (temperature, mixing, concentration, particle size, surface area, catalyst)
ACIDS AND BASES AND OXIDATION-REDUCTION REACTIONS	**C 8.1** Define the Arrhenius theory of acids and bases in terms of the presence of hydronium and hydroxide ions in water and the Bronsted-Lowry theory of acids and bases in terms of proton donors and acceptors.

Learning Objectives

STUDENTS SHOULD KNOW	UNDERSTAND (Essential Questions)	AND BE ABLE TO DO
▸ How changes in any of the following can increase or decrease the rate of a chemical reaction: • Temperature (average kinetic energy) • Rate of mixing, • **Concentration**, • Particle size, • Surface area, and • Presence of a **catalyst** ▸ How changes in these factors can produce a shift in direction of a chemical reaction (refer to Standard C 7.6)	▸ That these factors affect chemical reactions at the molecular level ▸ That reactions can be bidirectional when certain factors are changed and **shifts in equilibrium** occur (refer to Standard C 7.6)	▸ Identify examples that demonstrat an increase or decrease in the rate of a chemical reaction. ▸ Create an informational brochure explaining why silver jewelry tarnishes faster in warmer temperatures and how you could slow down this chemical reaction o prevent it from occurring altogether. ▸ Identify factors that can cause a shift in the direction (equilibrium) of a chemical reaction when provided sample chemical equations (refer to Standard C 7.6)
▸ That according to **Arrhenius's theory**, acids produce **hydrogen ions** (H^{1+} or H^{+}) when dissolved in water, and bases produce hydroxide ions (OH^{1-}) when dissolved in water ▸ Hydronium ions (H_3O^{1+}) result when water (H_2O) accepts an H^{1+} ion ▸ That according to the **Bronsted-Lowry theory**, an acid is a compound that is a **proton donor** and a base is a compound that is a **proton acceptor**: ▸ The hydrogen ion (H^{1+} or H^{+}) is a proton	▸ That acids and bases are defined at the molecular level ▸ An acid and a base can react with each other resulting in a neutralization reaction	▸ Compare and contrast why a compound is an acid or a base according to the Arrhenius theory versus the Bronsted-Lowry theory ▸ Explain why compounds are considered acids or bases based on these two theories, when given sample chemical equations ▸ Identify acids and bases in sample chemical equations based on both theories

Key topics in Chemistry	RELATED STANDARDS
ACIDS AND BASES AND OXIDATION-REDUCTION REACTIONS Connection: See Biology: Cycles of Life, Chapter 2, Basic Chemistry, subsection: *Acids, Bases and pH*	**C 8.2** Relate hydrogen ion concentrations to the pH scale and to acidic, basic, and neutral solutions. Compare and contrast the strengths of various common acids and bases (e.g., vinegar, baking soda, soap, citrus juice).

Learning Objectives

STUDENTS SHOULD KNOW	UNDERSTAND (Essential Questions)	AND BE ABLE TO DO
‣ That the **pH scale** describes the H^{1+} ion concentration of a solution ‣ That pH values range from 0 (acidic) to 14 (basic): • Solutions with a pH of 7 are neutral; • Solutions with a pH less than 7 are acidic; and • Solutions with a pH greater than 7 are basic. ‣ Examples of common acids and bases	‣ (refer to Standard C 7.6) That according to **Le Chatelier's principle**: • Solutions with low pH values have higher concentrations of H^{1+} ions and thus lower OH^{1-} concentrations • Solutions with high pH values have lower concentrations of H^{1+} ions and thus higher OH^{1-} concentrations ‣ That pH values indicate the strength or weakness of an acid or base	‣ Research common household acid and bases: • Determine the pH value of each • Determine if each is a strong or weak acid or base • Create a pH scale showing all of the researched acids and bases o a continuum • Include pictures and brief descriptions for each ‣ Determine if each has a high or lo concentration of hydrogen ions when provided examples of common acids and bases

EXPLORING LIQUIDS, SOLIDS, & GASES

PROBLEM OF THE DAY

1 class period

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STRAND Chemistry

TOPIC Kinetic molecular theory

LEARNING OBJECTIVES By the end of this activity, students should:

KNOW:
(factual information)

- That scientists have described 5 **phases of matter** (solids, liquids, gases, plasma, Bose-Einstein condensate)
- The three most common states of matter on earth (solids, liquids, and gases), and their properties based on the position and behavior of their particles (refer to Standard C 1.3)
  - Solids have a definite shape and volume
  - Liquids have definite volume but no definite shape
  - Gases have neither definite shape nor definite volume
- The relationship between temperature and the average kinetic energy of particles in matter
- That the tool to measure changes in average kinetic energy (particle speed) is the thermometer

UNDERSTAND:
(big ideas, concepts, essential questions)

- That all matter is made up of particles (atoms and/or molecules) held together by attracting forces
- That according to the kinetic molecular theory, the particles that make up matter are always in motion
- That during phase changes, the temperature and the average kinetic energy of particles in matter increases as the particles begin to move farther apart (solid → liquid → gas)
- Temperature is a measure of the average speed of particles

...and therefore be able to

DO

- Reflect on and write about everyday occurrences of phase changes
- Demonstrate how and why matter can change phase by adding energy to it (Kinesthetic activity)
- Create a cartoon, poster, or song that demonstrates a prediction about phase changes
- Make observations, raise questions, formulate hypotheses and predictions - both verbally & in writing
- Work collaboratively to reach the objectives (5Es)

These Learning Objectives are tied to the following

LEARNING STANDARDS

C 6.3

Using the kinetic molecular theory, describe and contrast the properties of gases, liquids, and solids. Explain, at the molecular level, the behavior of matter as it undergoes phase transitions.

PS 15

SIS1

- Make observations, raise questions, and formulate hypotheses.
- Observe the world from a scientific perspective.
- Pose questions and form hypotheses based on personal observations, scientific articles, experiments, and knowledge.

RESOURCES & MATERIALS

- Chalkboard or whiteboard
- pencils (regular and colored)
- small pieces of newspaper
- magnifying lens
- string (if needed)
- paper
- m&m candies or "energy tokens" with temperature written on it
- A terrific free trial for illustrating kinetic molecular theory that is available from: **http://www.atomicmicroscope.com**

LESSON DETAILS

Teacher will review the day's learning objectives, either reading them out loud or having students read different parts ~ 5 minutes

As a **pre-assessment**, the teacher will then ask students to reflect on and write about one or more of the following questions: ~ 10 minutes

- Why does the candy coating on an m&m melt in your mouth, not in your hand?
- Why does a basketball look like it has lost air when it's been left outside on a cold day?
- How does water form on the outside of a cold glass of water in the summertime?

LESSON DETAILS
(continued)

Have students look at the print on a newspaper with their eyes, then observe using a strong magnifying lens (in pairs). Then have students record their observations and present findings to the whole class. Students will (one hopes) point out that even though the letters appear solid, they are made up of very small dots with spaces in between them (the teacher can facilitate movement in this direction if needed) ~ 7 minutes

Ask students to hypothesize how this relates to all matter: solids, liquids, gases. Students should form a conclusion that, like the newsprint, even though it often appears to be solid or uniform, solid, liquid, and gaseous matter is made of very small particles ~ 5 minutes

Tell students they are going to pretend to be particles: first they will be particles in a solid, then particles in a liquid, and then in a gas.

Have students stand in a circle with their arms locked with one another (if students are not allowed to lock arms in your program, have them hold pieces of string so the string is taut). Instruct students to move in place just a little (swaying back and forth about 6 inches or so) as they are standing together. Point out that, as a solid, they have a definite volume and shape.

Give one m&m or energy token with a written temperature to each student. Tell the students you are giving them energy. Instruct students to move a little more (12 inches or so) and to move farther apart but still keep their arms locked together (or keep the string fairly taut). Point out that when matter gains energy, the particles speed up and the distance between them increases.

Give two m&m candies or energy tokens to each student. Have the students unlock their arms (or let go of the string) and slowly move around one another. Ask students what phase of matter they are representing now. Point out that as a group, they have a definite volume, but no definite shape.

Give students another candy or energy token and instruct them to move a little faster and a little further apart and eventually to make their way back to their seats. This represents a liquid which that has been heated and expands. This is how a thermometer works ~ 10 minutes

LESSON DETAILS
(continued)

Finally, have students (now sitting down and apart from one another) predict what would happen if they were given more energy. Students can either create a cartoon, poster, or song that demonstrates their prediction of the phase change/s.

For example, give the students the following instructions: "You are a cartoonist. Your task is to create a cartoon scenario illustrating the effect of temperature on the movement of molecules in a solid, liquid, or a gas. You will be using your cartoon to teach your classmates about the movement of molecules in the different states of matter and how an increase or decrease in temperature affects them. Be sure to address all aspects of the lesson objectives." The teacher will move around the room checking in with students, or pairs of students, working on their projects. ~10 minutes

HOMEWORK

Collect work to create a display at a later time; then hand out and go over homework assignment: "Create a list of the different solids, liquids, and gases encountered that day, and how temperature affects an example from each category."

DIFFERENTION OF:

Product

Choices include cartoons, posters, or songs.

Process

Multiple student grouping options (individual, pairs, small and whole group) and multiple learning styles are incorporated (e.g., kinesthetic, auditory, visual, etc.).

Content

Lesson is centered around standards from high school chemistry and middle school physical science, with tasks scaffolded to allow all students to demonstrate their cognitive readiness levels via questions, answers, and products.

EXTENSIONS

This would be a good opportunity to help students learn how to do a guided Web search at home or in school, as students could use the internet to find out other experiments that illustrate the effect of temperature. Two good websites are listed below, and there are many more! Students might also research the other two lesser-known states of matter: plasma & Bose-Einstein condensate.

http://chem4kids.com/

http://www.exploratorium.edu/hockey/index.html