Indiana Academic Standards for Chemistry
Standards Resource Guide Document

This Teacher Resource Guide has been developed to provide supporting materials to help educators successfully implement the Indiana Academic Standards fo Chemistry 1. These resources are provided to help you in your work to ensure all students meet the rigorous learning expectations set by the Academic Standarc Use of these resources is optional – teachers should decide which resource will work best in their school for their students.
This resource document is a living document and will be frequently updated.
Please send any suggested links and report broken links to:

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The resources, clarifying statements, and vocabulary in this document are for illustrative purposes only, to promote a base of clarity and common understanding Each item illustrates a standard but please note that the resources, clarifying statements, and vocabulary are not intended to limit interpretation or classroom applications of the standards.

Standard 1: Properties and States of Matter			
Indiana Academic Standard	**Clarifying Statement**	**Highlighted Vocabulary Words from the Standard Defined**	**Crosscutting Concept**

C.1.1 Differentiate between pure substances and mixtures based on physical and chemical properties.	Identify and explain why a sample that has multiple elements (water) can be pure (depending on the sample, not tap water). Students are able to identify physical and chemical properties in the laboratory. Separate mixtures using physical and chemical properties.	Pure substance – composed of only one type of particle (compound or element) Mixture – sample of two or more pure substances where each material maintains its own properties Physical property – aspect of matter that can be observed or measured without changing the chemical composition of the sample Chemical property – any property of matter that may only be observed and measured by performing a chemical change or chemical reaction.	Patterns Structure and Function
C.1.2 Use chemical properties, extensive, and intensive physical properties to identify substances.	Identifying various compounds and elements based on their chemical properties (flammable, oxidizer, etc.) extensive (mass, volume, etc.) and intensive physical properties (density, hardness, color, melting point, odor, etc.). Extensive properties of mass and volume can be used to calculate density (intensive) to help identify the substance. Extensive properties alone are not useful in the identification of a substance.	Chemical properties – any property of matter that may only be observed and measured by performing a chemical change or chemical reaction. Extensive properties – dependent on the amount of matter that is present in a sample Intensive properties – do not depend on the amount of matter present in a sample Physical properties – aspect of matter that can be observed or measured without changing the chemical composition of the sample Substances – a material with a definite chemical composition	Patterns Structure and Function
C.1.3 Recognize observable macroscopic indicators of chemical changes.	Use the indicators of energy released/absorbed during a reaction(heat, light, sound), gas production, precipitate formation, or color change to justify whether a chemical reaction occurred or if there was just a physical change.	macroscopic indicators – observations made by the naked eye chemical changes – the making and/or breaking of chemical bonds resulting in the formation of new chemical substances	Energy and matter

C.1.4 Describe physical and chemical changes at the particle level.	Students examine and build models of what samples look like at the microscopic level. Manipulate atoms/particles to see that chemical changes rearrange particles and break/form new bonds.	Physical changes – any change that does not change the chemical identity of a substance Chemical changes – the making and/or breaking of chemical bonds resulting in the formation of new chemical substances Particle – smallest individual units of a sample (formula units, molecules, atoms)	Structure and function Energy and Matter
C.1.5 Describe the characteristics of solids, liquids, and gases and changes in state at the macroscopic and microscopic levels.	Students look at defining characteristic of each state of matter. Students make/examine models of particles at the microscopic/macroscopic levels and how these particles behave in each of the states of matter.	Solid – state of matter characterized by structural rigidity and resistance to changes of shape or volume Liquid – state of matter characterized by nearly constant volume independent of pressure and conforms to the shape of its container. Gas – state of matter that expands freely to fill any space available Change in state – transition from one state of matter to another state of matter Macroscopic – visible to the naked eye/large scale Microscopic – visible only with a microscope or various technology/small scale/particle level	Cause and Effect Scale, proportion, and quantity Energy and Matter
C.1.6 Demonstrate an understanding of the law of conservation of mass through the use of particle diagrams and mathematical models.	Modeling a chemical reaction through diagrams, manipulatives so that as a chemical reaction occurs, the matter/atoms that make the reactants equal that in the final products, just rearranged and bonds formed/broke	Law of conservation of mass – matter can be changed from one form into another, but the total amount of mass remains the same Particle diagrams – visual depiction in which atoms and molecules are drawn as dots/circles Mathematical models – description of a system using equations	Patterns Scale, Proportion, and Quantity

C.1.7 Perform calculations involving density and distinguish among materials based on densities.	Identify density as an intensive property derived from two extensive properties. Identify unknown substance by calculating density and comparing to known values of various samples. Identify and use correct units for density. Calculate volume, mass, and density when two of the three values are known.	Density – mass per unit volume Material – sample of matter.	Scale, Proportion, and Quantity

Standard 2: Atomic Structure and the Periodic Table			
Indiana Academic Standard	**Clarifying Statement**	**Highlighted Vocabulary Words from the Standard Defined**	**Crosscutting Concept**
C.2.1 Using available experimental data, explain how and why models of atomic structure have changed over time.		Experimental data – quantities obtained through laboratory investigations Model – representation of a more complex item/relationship Atomic structure – the particles, amounts, and position of particles within an atom	Systems and System Models Structure and Function Stability and Change

C.2.2 Determine the number of protons, neutrons, and electrons in isotopes and calculate the average atomic mass from isotopic abundance data.		Protons – an elementary particle that is identical with the nucleus of the hydrogen atom, that along with the neutron is a constituent of all other atomic nuclei, that carries a positive charge numerically equal to the charge of an electron Neutron – an uncharged elementary particle that has a mass nearly equal to that of the proton and is present in all known atomic nuclei except the hydrogen nucleus Electron – a very small particle of matter that has a negative charge of electricity and that travels around the nucleus of an atom Isotopes – any of two or more species of atoms of a chemical element with the same atomic number and nearly identical chemical behavior but with differing atomic mass or mass number and different physical properties Average atomic mass – sum of the masse of its isotopes, each multiplied by the natural abundance of each Isotopic abundance data – relative number of atoms of different isotopes of one chemical element usually expressed as a percentage of all the long – lived isotopes of that element.	Structure and Function Scale, proportion, and quantity

C.2.3 Write the full and noble gas electron configuration of an element, determine its valence electrons, and relate this to its position on the periodic table.		Full electron configuration – distribution of electrons of a neutral atom Noble gas electron configuration – the loss or gain of electrons to achieve the stable electron configuration of a noble gas Element – smallest unit of matter that maintains its unique properties Valence electrons – electrons in the outer shell of an atom that often are involved in bonding. Periodic table – arrangement of all known elements in order of atomic number so that elements with similar atomic structure and properties appear in vertical columns	Pattern Cause and Effect System and system models
C.2.4 Use the periodic table as a model to predict the relative properties of elements based on the pattern of valence electrons and periodic trends.	Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, electronegativity, atomic radius, ionization energy, and reactions with oxygen	Periodic table – arrangement of all known elements in order of atomic number so that elements with similar atomic structure and properties appear in vertical columns Model – representation of a more complex item/relationship Properties – an attribute, quality, or characteristic of something Element – smallest unit of matter that maintains its unique properties Valence electrons – electrons in the outer shell of an atom that often are involved in bonding. Periodic trends – specific patterns that are present in the periodic table that illustrate different properties.	Pattern Cause and effect Structure and Function

C.2.5 Compare and contrast nuclear reactions with chemical reactions	Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.	Nuclear reactions – change in the energy or structure of an atomic nucleus (fission, fusion, or radioactive decay) Chemical reactions – process of rearrangement of the molecular or ionic structure of a substance (making or breaking chemical bonds), as opposed to change in physical form or a nuclear reaction	Energy and Matter Stability and change
C.2.6 Describe nuclear changes in matter, including fission, fusion, transmutations, and decays.	Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.	Nuclear changes – change in the number of protons or neutrons in the nucleus of an atom Matter – thing that has mass and takes up space Fission – splitting of a nucleus of an atom into two nuclei of lighter atoms and the release of energy Fusion – nuclei of light atoms join to form nuclei of heavier atoms Transmutation – the conversion of one element or nucleide into another either naturally or artificially Decay – nucleus of an unstable atom loses energy by emitting radiation	Energy and matter Stability and change Structure and function
C.2.7 Perform half-life calculations when given the appropriate information about the isotope.	Perform sample calculations and graph half-life to find time that has passed, original mass, final mass, and calculate half-life based on experimental data.	Half-life – the time it takes for half of a radioactive sample to decay to a more stable isotope Isotope – any of two or more species of atoms of a chemical element with the same atomic number and nearly identical chemical behavior but with differing atomic mass or mass number and different physical properties	Patterns Scale, proportion, and quantity

Standard 3: Bonding and Molecular Structure			
Indiana Academic Standard	**Clarifying Statement**	**Highlighted Vocabulary Words from the Standard Defined**	**Crosscutting Concept**
C.3.1 Investigate the observable characteristics of elements, ionic, and covalent compounds.	Examine conductivity, solubility, melting point, boiling point, etc. using lab data and observations	Elements – smallest unit of matter that maintains its unique properties Ionic compounds – chemical compound comprised of ions held together by electrostatic forces Covalent compounds – two or more nonmetal atoms bonded by sharing valence electrons	Patterns Structure and function
C.3.2 Compare and contrast how ionic and covalent compounds form.		Ionic compounds – chemical compound comprised of ions held together by electrostatic forces Covalent compounds – two or more nonmetal atoms bonded by sharing valence electrons	Structure and function Systems and system models
C.3.3 Draw structural formulas for simple molecules and determine their molecular shape.	Introduction to drawing structural formulas and simple molecular shapes emphasizing three dimensional molecules (water is bent because of lone pairs of electrons)	Structural formulas – a formula that shows the arrangement of atoms in the molecule of a compound Molecules – group of atoms held together by chemical bonds Molecular shape – three dimensional arrangement of the atoms bonded in a molecule	System and system models
C.3.4 Write chemical formulas for ionic compounds and covalent compounds given their names and vice versa.	Writing formulas and naming compounds for simple binary ionic and binary covalent compounds	Chemical formula – set of chemical symbols showing the elements present in a compound and their relative proportions	Patterns System and system models

C.3.5 Use laboratory observations and data to compare and contrast ionic, covalent, network, metallic, polar, and non-polar substances with respect to constituent particles, strength of bonds, melting and boiling points, and conductivity; provide examples of each type.	Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.]	Data – facts and statistics collected together for reference and analysis Ionic – Covalent – Network – Metallic – attraction between positively charged atomic nuclei of metal atoms and delocalized electrons Polar substances– compound in which the electric charge is not symmetrically distributed to where there is a separation of charge or partial charge Non-polar substances – compound composed of molecules that possess symmetric distribution of charge Constituent particles – Strength of bonds – strength with which a chemical bond holds two atoms together, measured in the amount of energy, kilocalories/mole, required to break the bond Melting point – temperature at which a solid transitions to a liquid at atmospheric pressure Boiling point – temperature at which a liquid transitions to a gas at atmospheric pressure Conductivity – degree to which a specified material conducts electricity	Cause and effect Structure and function Stability and change

C.3.6 Use structural formulas of hydrocarbons to illustrate carbon's ability to form single and multiple bonds within a molecule.	Introducing organic compounds and the formation of long chains, rings, double, and triple bonding between carbon	Structural formulas - – a formula that shows the arrangement of atoms in the molecule of a compound Hydrocarbons – simplest organic compounds containing only carbon and hydrogen Single bonds – a chemical bond in which one pair of electrons is shared between two atoms. Multiple bonds – a chemical bond in which two or more pairs of electrons are shared between two atoms Molecule - group of atoms held together by chemical bonds	Structure and function System and system model

Standard 4: Reactions and Stoichiometry			
Indiana Academic Standard	**Clarifying Statement**	**Highlighted Vocabulary Words from the Standard Defined**	**Crosscutting Concept**
C.4.1 Describe, classify, and give examples of various kinds of reactions: synthesis (i.e., combination), decomposition, single displacement, double displacement, acid/base, and combustion.	Extension: Electrochemistry	Synthesis – two or more simple substances combine to form a more complex product Decomposition – separation of a chemical compound into elements or simpler compounds Single displacement – an element or ion moves out of one compound and replaced by another Double displacement – two compounds react and the cation and anion of the two reactants switch to form two new compounds Acid/base – exchange of one or more hydrogen ions between species Combustion – oxygen reacts with another compound, usually a hydrocarbon	Patterns Cause and effect System and system models Energy and matter

C.4.2 Predict products of simple reactions as listed in C.4.1.	When given two compounds/reactants, students can predict products by classifying the type of reaction	Products – new compounds formed in a chemical reaction	Stability and change Patterns
C.4.3 Balance chemical equations and use the law of conservation of mass to explain why this must be true.	Extension: Identify REDOX reactions/Balance REDOX reactions	Balance – using coefficients to ensure that each type of atom and the total charge of reactants matches the total number of atoms and charge of products. Law of conservation of mass – mass in an isolated system is neither created nor destroyed by chemical reactions or physical transformations.	Scale, proportion, and quantity
C.4.4 Apply the mole concept to determine the mass, moles, number of particles or volume of a gas at STP, in any given sample, for an element or compound.	Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale	Mole – a chemical unit defined to be 6.022 x 10^23 molecules, atoms, or some other unit Mass – measure of the amount of matter in an object Number of particles – molecules, formula units, atoms Volume – quantity of three-dimensional space occupied by a solid, liquid, or gas STP – standard temperature and pressure, 273.15 K and a pressure of 1 atm Element – atoms that all have the same number of protons Compound – two or more elements chemically bonded together	Scale, proportion, and quantity Energy and matter

C.4.5 Use a balanced chemical equation to calculate the quantities of reactants needed and products made in a chemical reaction that goes to completion.	Examining limiting reagents, excess reagents, and left-over materials. Extension can be when the reaction does not go to equilibrium(examining equilibrium constants)	Balanced chemical equation – using coefficients to ensure that each type of atom and the total charge of reactants matches the total number of atoms and charge of products to reflect the law of conservation of mass Reactant – substances initially present in a chemical reaction Product – new compounds formed in a chemical reaction Chemical reaction – process of rearrangement of the molecular or ionic structure of a substance (making or breaking chemical bonds), as opposed to change in physical form or a nuclear reaction Completion – a reaction in which essentially all of the reactants react to form products	Scale, proportion, and quantity
C.4.6 Perform calculations to determine the composition of a compound or mixture when given the necessary information.	% composition by mass for each element in a compound when given the formula, % composition by mass of various compounds/elements in a mixture	Composition – proportions of various elements/compounds in a sample Compound – substance formed when two or more elements are chemically bonded together Mixture – sample of two or more pure substances where each material maintains its own properties	Scale, proportion, and quantity Structure and function
C.4.7 Apply lab data to determine the empirical and molecular formula of a compound.	Use percent composition data to calculate the empirical formula and with the molar mass, find the molecular formula	Empirical formula– simplest whole number ratio of a chemical formula Molecular formula– expression of the number and type of atoms that are present in a molecule of a substance (can be a multiple of an empirical formula) Compound – substance formed when two or more elements are chemically bonded together	Scale, proportion, and quantity Structure and function

Standard 5: Behavior of Gases			
Indiana Academic Standard	**Clarifying Statement**	**Highlighted Vocabulary Words from the Standard Defined**	**Crosscutting Concept**
C.5.1 Use the kinetic molecular theory with the combined and ideal gas laws to explain changes in volume, pressure, moles and temperature of a gas.		Kinetic molecular theory – individual gas particles interact with one another and relates microscopic gas to macroscopic gas behavior Combined gas law – combination of Charles's, Boyle's, and Gay-Lussac's law relating pressure, volume, and temperature Ideal gas law –relationship of variables in a hypothetical ideal gas, combination of Boyle's, Charles's, and Avogadro's law. Volume – quantity of three-dimensional space occupied by a solid, liquid, or gas Pressure – force exerted by the substance per unit area on another substance Moles - a chemical unit defined to be 6.022 x 10^23 molecules, atoms, or some other unit Temperature - measure of thermal energy Gas - state of matter that expands freely to fill any space available	Scale, proportion, and quantity Cause and effect
C.5.2 Apply the ideal gas equation (PV = nRT) to calculate the change in one variable when another variable is changed and the others are held constant.		Ideal gas equation – equation that equates the product of the pressure and the volume of a gas to the product of the number of moles of gas, the temperature, and gas constant Variable – factor, trait, or condition that can exist in differing amounts or types Constant – a fixed value, non-varying	Scale, proportion, and quantity Cause and effect
C.5.3 Use lab data and a balanced chemical equation to calculate volume of a gas at STP and non STP conditions, assuming that the reaction goes to completion and the ideal gas law holds.		Balanced chemical equation – using coefficients to ensure that each type of atom and the total charge of reactants matches the total number of atoms and charge of products to reflect the law of conservation of mass	Scale, proportion, and quantity Systems and system models

Standard 6: Thermochemistry			
Indiana Academic Standard	**Clarifying Statement**	**Highlighted Vocabulary Words from the Standard Defined**	**Crosscutting Concept**
C.6.1 Explain that atoms and molecules are in constant motion and that this motion increases as thermal energy increases.		Motion –moving or changing place or position Thermal energy – internal energy of an object due to kinetic energy of its atoms and/or molecules	Scale, proportion, and quantity Cause and effect
C.6.2 Distinguish between the concepts of temperature and heat flow in macroscopic and microscopic terms.		Temperature – measure of thermal energy Heat flow – process whereby heat moves from one body or substance to another by radiation, conduction, convection, or a combination of these methods Macroscopic – visible to the naked eye/large scale Microscopic – visible only with a microscope or various technology/small scale/particle level	Scale, proportion, and quantity Energy and matter
C.6.3 Classify chemical reactions and phase changes as exothermic or endothermic based on enthalpy values. Use a graphical representation to illustrate the energy changes involved	Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved	Phase changes – transition between solid, liquid, and gaseous phases Exothermic – accompanied by the release of heat Endothermic – accompanied by or requiring the absorption of heat Enthalpy – measure of energy in a thermodynamic system	Energy and matter

C.6.4 Perform calculations involving heat flow, temperature changes, and phase changes by using known values of specific heat, phase change constants, or both.		Specific heat – thermal energy required to raise the temperature of one gram of a given substance by one degree Celsius Phase change constants – rate of energy required to change a mass of sample from one state to another(heat of fusion, heat of vaporization)	Scale, proportion, and quantity Energy and matter

Standard 7: Solutions			
Indiana Academic Standard	**Clarifying Statement**	**Highlighted Vocabulary Words from the Standard Defined**	**Crosscutting Concept**
C.7.1 Describe the composition and properties of solutions.		Composition – proportions of various elements/compounds in a sample Property – characteristic of a substance Solution- homogenous mixture composed of two or more substances	Scale, proportion, and quantity
C.7.2 Explain how temperature, pressure, and polarity of the solvent affect the solubility of a solute.		Pressure – force exerted by the substance per unit area on another substance Polarity – separation of electric charge leading to a molecule having a electric dipole or multipole moment Solubility – chemical property referring to the ability for a given substance, solute, to dissolve in a solvent Solute – substance dissolved in another substance, known as a solvent	Cause and effect

C.7.3 Describe the concentration of solutes in a solution in terms of molarity. Perform calculations using molarity, mass, and volume. Prepare a sample of given molarity provided a known solute.		Concentration – ratio of solute per total volume of a mixture Molarity – moles of solute per liter of solution	Scale, proportion, and quantity

Standard 8: Acids and Bases			
Indiana Academic Standard	**Clarifying Statement**	**Highlighted Vocabulary Words from the Standard Defined**	**Crosscutting Concept**
C.8.1 Classify solutions as acids or bases and describe their characteristic properties.		Acid – chemical substance whose aqueous solutions are characterized by a sour taste, turn blue litmus red, and react with bases to form salts Base – chemical substance that in aqueous solution are slippery to the touch, taste bitter, change red litmus paper blue, and react with acids to form salts Characteristic properties – chemical or physical property that helps identify and classify substances	Patterns Systems and system models
C.8.2 Compare and contrast the strength of acids and bases in solutions.	Examine household chemicals and a variety of stock laboratory chemicals	Strength – concentration of ions in solution	Structure and function

C.8.3 Given the hydronium ion and/or the hydroxide ion concentration, calculate the pH and/or the pOH of a solution. Explain the meanings of these values.	Extension: Titrations, finding the concentration/molarity of an unknown acid/base Extension: Buffers	Hydronium ion – hydrogen ion bonded to a molecule of water found in aqueous systems Hydroxide ion – diatomic anion with an oxygen and hydrogen covalently bonded and carries a negative charge pH – figure expressing the acidity or alkalinity based on hydrogen ion concentration of a solution on a logarithmic scale on which 7 is neutral, lower acidic, and higher basic pOH – figure expressing the acidity or alkalinity based on hydroxide ion concentration of a solution on a logarithmic scale on which 7 is neutral, higher acidic, and lower basic	Scale, proportion, and quantity Stability and change

Crosscutting Concepts

1. *Patterns.* Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.
2. *Cause and effect: Mechanism and explanation.* Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.
3. *Scale, proportion, and quantity.* In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.
4. *Systems and system models.* Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.
5. *Energy and matter: Flows, cycles, and conservation.* Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.
6. *Structure and function.* The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.
7. *Stability and change.* For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.