High School Science

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Draft Chemistry Framework-August 2004 (.pdf file)
Draft Chemistry Framework- August 2004 (.doc file)

Draft Chemistry Blueprints -July 2002

Draft for

MCPS High School Science

Chemistry Framework

August 2004

Chemistry Curriculum Revision Team

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This draft Framework was created by teachers as a first step in the current revision of the course curriculum. Its purpose is to serve as a vehicle for review, discussion and critique by concerned stakeholders who are encouraged to provide written feedback to the Science Office for specific improvements and changes. Comments will be collected and reviewed and appropriate changes will be made. This will lead to the new course curriculum, which will align with and exceed the Maryland Learning Outcomes.
Frameworks are intended to provide the underlying structure of a course and contain two major components: 1) the Rationale and 2) the Scope and Sequence. The Rationale contains the goal, enduring understandings, content description, and instructional approach description of the course. The Scope and Sequence is a collection of the course indicators. This course Framework will lead to course Blueprints which will describe the "why, what and how" for each unit. Blueprints will lead to the Curriculum Guide which will contain concept maps, model lesson plans, model assessments, and other course resources.

Chemistry Rationale

Goal
The goal of Chemistry is to instill in the student a curiosity about matter and its interactions; to initiate a lifetime of using an organized, evidence based approach to solving problems; and to recognize the central significance of chemistry to the understanding of all other sciences and its applications to every day lives and real world situations.

Enduring Understandings

1. Chemistry is recognized as significant in its application to other disciplines and the world.
2. Ideas are expressed symbolically, numerically, and graphically.
3. Behavior and properties of materials are organized, classified, and predicted utilizing periodic trends.
4. Mathematical relationships are interpreted and manipulated to model the real world.
5. Experimental investigations are designed, analyzed, interpreted, applied, and communicated through the laboratory process.

Content
Chemistry, the study of matter and its interactions, uses an organized approach to solving problems and has central significance to the understanding of all other sciences. The content of the chemistry curriculum is focused to challenge the reasoning and analytical skills of responsible and academically motivated students. Chemistry is both conceptual and mathematical. Chemistry uses math to explore and model the interactions of matter. Students will apply their knowledge of chemistry to current events, such as hazardous materials, environmental issues, and development of synthetic materials.

Instructional Approach
Instruction and learning are organized around the 5E's Inquiry Model. The teacher functions as facilitator or coach to nurture the students' growth to become independent learners. A variety of teaching strategies are used to promote inquiry, including laboratory experiments, demonstrations, direct instruction, current events, visual presentations and cooperative learning, as appropriate to the lesson and prior knowledge of the students. Time is provided to ensure that problem analysis, as well as solution strategies, are addressed. Students synthesize unifying principles from the course of study, make interdisciplinary connections, and apply these understandings to real world situations. The teacher provides opportunities for students to use technology and apply their knowledge and skills to projects and learning experiences. Teachers engage students in effective techniques of reading, writing, and mathematics to extend their understandings of the content. Assessment is frequent, ongoing, and embedded in student learning experiences. Methods of evaluation incorporate rubrics and include pre-, formative, and summative assessment to evaluate teaching and learning. Teachers set high standards with challenging and rigorous expectations for all students and provide differentiation of instruction and learning as appropriate.

Chemistry Scope and Sequence

The Scope and Sequence is identified by numbered goals, expectations, and indicators. The indicators from the Maryland State Performance Program Core Learning Goal 1 are shown here. These are used throughout the course. All concept indicators, Goal 4, are addressed by using Goal 1 indicators as the primary vehicles of instruction. Their placement at the beginning of this document does not imply that they are taught first or that they are taught only at the beginning of the course.

Skills and Processes Indicators
The student will:

HS1.1.1 recognize that real problems have more than one solution and decisions to accept one over another are made on the basis of many issues.
HS1.1.2 modify or affirm scientific ideas according to accumulated evidence.
HS1.1.3 critique arguments that are based on faulty, misleading data or on the incomplete use of numbers.
HS1.1.4 recognize data that are biased.
HS1.1.5 explain factors that produce biased data (incomplete data, using data inappropriately, conflicts

of interest, etc.).
HS1.2.1 identify meaningful, answerable scientific questions.
HS1.2.2 pose meaningful, answerable scientific questions.
HS1.2.3 formulate a working hypothesis.
HS1.2.4 test a working hypothesis.
HS1.2.5 select appropriate instruments and materials to conduct an investigation.
HS1.2.6 identify appropriate methods for conducting an investigation (independent and dependent variables, proper controls, repeat trials, appropriate sample size, etc.).
HS1.2.7 use relationships discovered in the lab to explain phenomena observed outside the laboratory.
HS1.2.8 defend the need for verifiable data.
HS1.3.1 develop and demonstrate skills in using lab and field equipment to perform investigative techniques.
HS1.3.2 recognize safe laboratory procedures.
HS1.3.3 demonstrate safe handling of the chemicals and materials of science.
HS1.3.4 learn the use of new instruments and equipment by following instructions in a manual or from oral direction.
HS1.4.1 organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate intervals, independent and dependent variables on correct axes and appropriate title).
HS1.4.2 analyze data to make predictions, decisions, or draw conclusions.
HS1.4.3 use experimental data from various investigators to validate results.
HS1.4.4 determine the relationships between quantities and develop the mathematical model that describes these relationships.
HS1.4.5 check graphs to determine that they do not misrepresent results.
HS1.4.6 describe trends revealed by data.
HS1.4.7 determine the sources of error that limit the accuracy or precision of experimental results.
HS1.4.8 use models and computer simulations to extend his/her understanding of scientific concepts.
HS1.4.9 use analyzed data to confirm, modify, or reject an hypothesis.
HS1.5.1 demonstrate the ability to summarize data (measurements/observations).
HS1.5.2 explain scientific concepts and processes through drawing, writing, and/or oral communication.
HS1.5.3 use computers and/or graphing calculators to produce the visual materials (tables, graphs, and spreadsheets) that will be used for communicating results.
HS1.5.4 use tables, graphs, and displays to support arguments and claims in both written and oral communication.
HS1.5.5 create and/or interpret graphics. (scale drawings, photographs, digital images, field of view, etc.)
HS1.5.6 read a technical selection and interpret it appropriately.
HS1.5.7 use, explain, and/or construct various classification systems.
HS1.5.8 describe similarities and differences when explaining concepts and/or principles.
HS1.5.9 communicate conclusions derived through a synthesis of ideas.
HS1.6.1 use ratio and proportion in appropriate situations to solve problems.
HS1.6.2 use computers and/or graphing calculators to perform calculations for tables, graphs, or spreadsheets.
HS1.6.3 express and/or compare small and large quantities using scientific notation and relative order of magnitude.
HS1.6.3.A select appropriate units to describe quantities.
HS1.6.4 manipulate quantities and/or numerical values in algebraic equations.
HS1.6.5 judge the reasonableness of an answer.
HS1.7.1 apply the skills, processes, and concepts of the course to societal issues.
HS1.7.2 identify and evaluate the impact of scientific ideas and/or advancements in technology on society.
HS1.7.3 describe the role of science in the development of literature, art, and music.

HS1.7.4 recognize mathematics as an integral part of the scientific process.
HS1.7.5 investigate career possibilities in the various areas of science.
HS1.7.6 explain how development of scientific knowledge leads to the creation of new technology and how technological advances allow for additional scientific accomplishments.
The following indicators come from MSPP Core Learning Goal 4 (Concepts of Chemistry) and are addressed by using Goal 1 (Skills and Processes) indicators as the primary vehicles of instruction.

Chemistry Concept Indicators
The student will:
Expectation 1: The student will explain that atoms have structure and this structure serves as the basis for the properties of elements and the bonds that they form.
HS.4.1.1 analyze the structure of the atom and describe the characteristics of the particles found there.
HS4.1.1.1 describe the characteristics of protons, neutrons and electrons in terms of location, charge and mass.
HS4.1.1.2 distinguish between the nucleus and electron cloud.
HS4.1.1.3a identify the atomic number and mass number given the periodic table.
HS4.1.1.3b identify isotopes of an element based on number of neutrons and/or atomic mass.
HS4.1.1.3c calculate numbers of protons, neutrons and electrons for atoms given mass and the periodic table.
HS4.1.1.3d write nuclide symbols and names that identify specific isotopes.
HS4.1.1.4a explain how the average atomic mass represents the weighted average of the isotopes of an element.
HS4.1.1.4b express atomic mass in atomic mass units.
HS4.1.1.5 describe the characteristics of a neutral atom.
HS4.1.1.6 trace the historical development and/or experimental evidence for the existence and structure of the atom, including the contributions of Democritus, Dalton, Thomson, Rutherford and Bohr, and the development of the electron cloud model.
HS4.1.1.A illustrate the structure of the atom by using the Bohr model, including the charge, relative mass and location of the sub-atomic particles.
HS4.1.1.B use atomic mass, atomic number, and charge to identify neutral atoms, ions, and isotopes.
HS4.1.1.C describe electron configurations for the first twenty elements.
HS4.1.1.D describe electron configurations for all elements and justify exceptions. (H)
HS4.1.1.E calculate an element's average atomic mass. (H)
HS4.1.2 demonstrate that the arrangement and number of electrons and the properties of elements repeat in a periodic manner illustrated by their arrangement in the periodic table.
HS4.1.2.1a locate groups/families on the periodic table, including groups 1-18, and the Alkali Metals, Alkaline Earth Metals, Transition Metals, Halogens, Noble Gases, Lanthanide Series and Actinide Series.
HS4.1.2.1b describe the properties of the groups/families on the periodic table.
HS4.1.2.1c locate periods 1-7 on the periodic table.
HS4.1.2.2 describe how the trends of valence electrons, atomic radius, ionization energy, relative chemical reactivity, and metallic/nonmetallic properties behave in groups 1,2 and 13-18.
HS4.1.2.A trace the historical development of the periodic table.
HS4.1.2.B explain why periodic trends follow observed patterns.
HS4.1.2.C classify elements as metals, nonmetals and metalloids based on common physical and chemical properties and position on periodic table.
HS4.1.2.D determine the number of valence electrons for a specific element, given a periodic table.
HS4.1.2.E use families, periods, and common family names in discussions of periodic trends.
HS4.1.2.F predict chemical and physical properties based on an element's location on the periodic table.
HS4.1.3 explain how atoms will interact with other atoms through the transfer and sharing of electrons in the formation of chemical bonds.
HS4.1.3.1a relate the charge of ions to the number of electrons gained or lost.

HS4.1.3.1b predict oxidation number based on valence electrons or location on the periodic table.
HS4.1.3.1c classify ions as cations or anions.
HS4.1.3.2 define chemical bonds.
HS4.1.3.3a define ionic bonds.
HS4.1.3.3b characterize bonds as ionic based on the metal-nonmetal combination.
HS4.1.3.3c explain the role of valence electrons in ionic bond formation.
HS4.1.3.4a define covalent bonds.
HS4.1.3.4b characterize bonds as covalent based on the nonmetal-nonmetal combination.
HS4.1.3.4c explain the role of valence electrons in covalent bond formation.
HS4.1.3.4d explain the formation of single, double, triple covalent bonds.
HS4.1.3.5 use the concept of electronegativity to define bond polarity.
HS4.1.3.6 define metallic bonds.
HS4.1.3.7 compare ionic and covalent bonds in terms of bond energy.
HS4.1.3.8 distinguish among metallic, ionic, and covalent solids in terms of solubility, melting point, boiling point and conductivity.
HS4.1.3.A compare the characteristics of the neutral atom to its ion.
HS4.1.3.B construct electron dot structures of atoms and ions to demonstrate the formation of ionic and covalent compounds.
HS4.1.3.C define ground and excited states.
HS4.1.3.D explain the formation of emission spectra of elements.

Expectation 2: The student will explain how the properties of compounds are related to the arrangement and type of atoms they contain.
HS4.2.1 summarize that the properties of a molecule are determined by the atoms it contains and their arrangement.
HS4.2.1.1 apply the concept of polar and non-polar molecules to explain and predict the solubility of substances.
HS4.2.1.2 determine the molecular geometry through tetrahedral compounds based on Lewis dot diagrams and octet rule.
HS4.2.1.3a define and explain the shape and polarity of the water molecule.
HS4.2.1.3b observe and explain the change in density of water as phase changes occur.
HS4.2.1.3c describe the use of water as the “universal” solvent.
HS4.2.1.3d conceptually explain hydrogen bonding.
HS4.2.1.3e explain the high surface tension and specific heat of water.
HS4.2.1.A analyze molecular geometry in order to classify molecules as polar or non-polar.
HS4.2.1.B compare inter-molecular and intra-molecular forces and relate them to properties of substances. (H)
HS4.2.2 explain why organic compounds are so numerous and diverse.
HS4.2.2.1 distinguish between inorganic and organic compounds in terms of carbon content.
HS4.2.2.2 define hydrocarbons.
HS4.2.2.3 recognize the ability of carbon to form chains and make rings.
HS4.2.2.A name straight chain organic compounds (alkanes: methane through decane, including formulas).
HS4.2.2.B recognize alkenes and alkynes, carboxcylic and alcohol functional groups.
HS4.2.2.C recognize the role of organic compounds as fuels, plastics, polymers and biological compounds.
HS4.2.3a describe the properties of solutions.
HS4.2.3b explain how solutions form.
HS4.2.3.1a identify the solute and solvent of a solution.
HS4.2.3.1b define solubility.
HS4.2.3.2 compare solutions to suspensions and colloids.
HS4.2.3.3 recognize alloys and gaseous solutions.
HS4.2.3.4a distinguish among the types of solutions by degree of concentration, dilute through

supersaturated.
HS4.2.3.4b define molarity conceptually.
HS4.2.3.4c interpret solubility curves.
HS4.2.3.5a describe the process of dissociation/ionization.
HS4.2.3.5b explain how the factors of solute surface area, temperature and agitation influence the rate of dissociation/ionization.
HS4.2.3.6 define electrolytes in terms of composition and properties.
HS4.2.3.A differentiate among elements, compounds, mixtures and solutions.
HS4.2.3.B calculate the quantities needed to prepare molar solutions.
HS4.2.3.C describe how to prepare molar solutions from his/her own calculations.
HS4.2.3.D calculate concentration of the solution by molality. (H)
HS4.2.3.E predict a boiling point elevation and a freezing point depression conceptually.
HS4.2.3.F calculate boiling point elevation and freezing point depression. (H)
HS4.2.4 differentiate among acids, bases and salts based on their properties.
HS4.2.4.1 define an acid or base using the Arrhenius definition including the hydronium ion.
HS4.2.4.2 recognize the ability of water to act as either an acid or a base.
HS4.2.4.3 describe a neutralization reaction.
HS4.2.4.4 describe the characteristics of salts.
HS4.2.4.5 utilize and recognize indicators to identify acids and bases.
HS4.2.4.6 describe the function of buffers.
HS4.2.4.A define an acid or base using the Bronsted-Lowry definition.
HS4.2.4.B distinguish between strong and weak acids and bases.
HS4.2.4.C describe concentrated and dilute as they apply to acids and bases.
HS4.2.4.D describe the pH scale.
HS4.2.4.E predict whether a substance is an acid or base based on its pH value.
HS4.2.4.F explain the relationship between the hydronium ion concentration and the pH.
HS4.2.4.G calculate pH given the hydronium or hydroxide ion concentration (whole numbers without calculators).
HS4.2.4.H Using titration data, determine the concentration of an unknown acid or base.
HS4.2.4.I use calculations to determine the relationship between pH, pOH, and Kw. (H)
HS4.2.4.J calculate Ka and Kb. (H)

Expectation 3: The student will apply the basic concepts of thermodynamics (thermochemistry) to phases of matter and phase and chemical changes.
HS4.3.1 illustrate that thermal energy in a material consists of the ordered and disordered motions of its colliding particles.
HS4.3.1.1 differentiate between thermal energy and temperature.
HS4.3.1.2 define the phase changes of matter.
HS4.3.1.3a interpret the different parts of a heating/cooling curve in terms of motion, kinetic energy and organization of particles.
HS4.3.1.3b describe the changes in particle motion and organization between phase changes.
HS4.3.1.3c identify the melting/freezing and boiling point on a heating/cooling curve.
HS4.3.2 describe observed changes in pressure, volume or temperature of a sample in terms of macroscopic changes and the behavior of particles.
HS4.3.2.1 describe the effect of pressure or volume changes to a sample of solid, liquid or gas when temperature is held constant.
HS4.3.2.2. describe the effect of pressure or temperature changes to a sample of solid, liquid or gas when volume is held constant.
HS4.3.2.3 describe the effect of temperature or volume changes to a sample of solid, liquid or gas when pressure is held constant.
HS4.3.2.A classify matter as solids, liquids, and gases, in reference to the relative position, motion and energy of particles.
HS4.3.2.B apply the combined and ideal gas laws in calculations.

HS4.3.2.C describe kinetic theory of ideal gases at STP.
HS4.3.2.D apply Graham's law and Dalton's Law in calculations. (H)
HS4.3.2.E manipulate the ideal gas law in ideal gas stoichiometry problems. (H)
HS4.3.3 explain why the interactions among particles involve a change in the energy system.
HS4.3.3.1 define exothermic changes in terms of bond formation, dissociation and thermal energy release.
HS4.3.3.2 define endothermic changes in terms of bond breaking, dissociation and thermal energy absorption.
HS4.3.3.A state that the total amount of energy in any isolated system remains constant.
HS4.3.3.B define specific heat.
HS4.3.3.C use the law of conservation of energy to solve calorimetry problems.
HS4.3.3.D explain that all systems tend towards disorder and lower energy.
HS4.3.3.E define activation energy.
HS4.3.3.F analyze energy graphs for chemical reactions.
HS4.3.3.G predict the sign of DH for chemical changes. (H)
HS4.3.3.H use Hess's law to calculate the energy of a reaction. (H)

Expectation 4: The student will explain how and why substances are represented by formulas.
HS4.4.1 illustrate that substances can be represented by formulas.
HS4.4.1.1a determine the number and types of atoms represented by a given formula.
HS4.4.1.1b describe the function of subscripts in a chemical formula.
HS4.4.1.2a write symbols to represent elements, including diatomic elements, given a periodic table.
HS4.4.1.2b write symbols to represent the following polyatomic ions: NH4+1, OH-1, NO3-1, NO2-1, ClO3-1, ClO2-1, HCO3-1, CO3-2, SO4-2, SO3-2, PO4-3, PO3-3 given an ion chart.
HS4.4.1.3a write names for acids using the binary naming system.
HS4.4.1.3b write names for oxyacids containing the polyatomic ions NO3-1, NO2-1, ClO3-1, ClO2-1, HCO3-1, CO3-2, SO4-2, SO3-2, PO4-3, PO3-3.
HS4.4.1.4 write formulas for ionic and molecular compounds including binary compounds, polyatomic ions and common acids and bases, when given the name, periodic table and ion chart.
HS4.4.1.5 write the name of ionic and molecular compounds, including binary compounds, polyatomic ions and common acids and bases, when given the formula, periodic table and ion chart.
HS4.4.1.A identify traditional nomenclature (-ic and -ous suffixes). (H)
HS4.4.2 demonstrate that chemical reactions can be represented by symbolic or word equations that specify all reactants and products involved.
HS4.4.2.1 transpose word equations into symbolic chemical equations.
HS4.4.2.2 transpose symbolic chemical equations into word equations.
HS4.4.2.A distinguish between physical and chemical changes.
HS4.4.3.1 define the mole in terms of Avogadro's number.
HS4.4.3.2 explain the relationship between moles and mass.
HS4.4.3.3 explain the relationship between moles and particles.
HS4.4.3.4 calculate the formula mass of a compound using the periodic table
HS4.4.3.5 calculate the mass percent composition of a compound given the formula, formula mass and periodic table
HS4.4.3.A utilize dimensional analysis to convert between moles and mass.
HS4.4.3.B utilize dimensional analysis to convert between moles and particles.
HS4.4.3.C utilize dimensional analysis to perform particle to mass and mass to particle calculations. (H)
HS4.4.3.D use laboratory data to calculate the empirical and molecular formula of a compound. (H)

Expectation 5: The student will explain that matter undergoes transformations, resulting in products that are different from the reactants.
HS4.5.1 describe the general types of chemical reactions (synthesis, decomposition, combustion, single displacement and double displacement)

HS4.5.1.1 identify synthesis and decomposition reactions given balanced formula equation or written description.
HS4.5.1.2 identify combustion reactions given balanced formula equation or written description.
HS4.5.1.3a identify single displacement reactions given balanced formula equation or written description.
HS4.5.1.3b apply the activity series to determine if single displacement reactions will occur.
HS4.5.1.4a identify double displacement reactions given balanced formula equation or written description.
HS4.5.1.4b apply solubility rules to predict if a precipitate will form in a double displacement reaction
HS4.5.1.A predict the products of chemical reactions based on the type of reaction. (H)
HS4.5.1.B write net ionic equations. (H)
HS4.5.2 use coefficients to balance simple chemical equations.
HS4.5.2.1 apply the Law of Conservation of Mass to account for the same number of atoms of each type appearing in both the reactants and products.
HS4.5.2.2a explain the meaning of coefficients in chemical equations.
HS4.5.2.2b differentiate between coefficients and subscripts in terms of their use and meaning.
HS4.5.3 demonstrate that adjusting quantities of reactants may affect the amounts of products formed.
HS4.5.3.1 use the coefficients of a balanced equation to predict amounts of reactants and products at the molecular and mole level.
HS4.5.3.A use the coefficients of a balanced equation to predict the mass of products formed by a specified mass of a reactant. (H)
HS4.5.3.B manipulate the limiting reagent concept qualitatively.
HS4.5.3.C determine limiting and excess reagents quantitatively to predict percent yield. (H)
HS4.5.4 recognize that chemical reactions occur at different speeds.
HS4.5.4.1a explain that in order for atoms to react they must collide with sufficient energy.
HS4.5.4.1b describe the direct relationship between reaction rate and frequency of molecular collisions.
HS4.5.4.2 describe the effects of surface area, temperature and concentration on the frequency of molecular collisions.
HS4.5.4.3 explain the concept of catalyst behavior.
HS4.5.5.A describe systems at equilibrium.
HS4.5.5.B describe factors that affect systems at equilibrium.
HS4.5.5.C predict the effect of a change (stress) on a system at equilibrium.
HS4.5.5.D determine the equilbrium expression given a chemical equation. (H)
HS4.5.5.E determine the equilibrium constant (Keq) given equilibrium concentrations. (H)

Explanation of Codes Used in Indicators

HS1 refers to MSPP Core Learning Goal #, 1= Process Skills, 2=Earth Science, 3= Biology, 4=Chemistry, 5=Physics, 6=Environmental Science

Second decimal place refers to MSPP expectation related to the goal.
Third decimal place refers to MSPP indicator related to the expectation.
Fourth decimal place refers to MSPP assessment limit or "at least item" related to the indicator.
Any additional decimal places refer to MCPS extensions added to MSPP "assessment limit" or "at least item."

Small letters such as "a," or "b" identify an MSPP indicator that is subdivided into separate MCPS indicators.

Italics identify the wording or intent of the MSPP Core Learning Goal.
Capital Letters identify a MCPS indicator that is not an MSPP indicator.
(H) identifies an indicator that will be assessed in MCPS Honors level courses.

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This page was created by Michael Szesze, Program Supervisor for Science.

This page was created on January 7, 2002 and last modified on February 11, 2005.
URL: http://www.mcps.k12.md.us/curriculum/science/hs/chemframework.htm