

**Michigan High School Science
Contents statements mapping**

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CHEMISTRY	Boardworks High School Chemistry Presentation
C2.1x Chemical Potential Energy	
C2.1a Explain the changes in potential energy (due to electrostatic interactions) as a chemical bond forms and use this to explain why bond breaking always requires energy.	Bonds and Activation Energy Covalent Bonding Electronegativity Ionic Bonding
C2.1b Describe energy changes associated with chemical reactions in terms of bonds broken and formed (including intermolecular forces).	Bonds and Activation Energy Endothermic Reactions Exothermic Reactions Intermolecular Forces
C2.1c Compare qualitatively the energy changes associated with melting various types of solids in terms of the types of forces between the particles in the solid.	Comparing Bonding
C2.2 Molecules in Motion	
C2.2a Describe conduction in terms of molecules bumping into each other to transfer energy. Explain why there is better conduction in solids and liquids than gases.	-
C2.2b Describe the various states of matter in terms of the motion and arrangement of the molecules (atoms) making up the substance.	Particles in Action
C2.2x Molecular Entropy	
C2.2c Explain changes in pressure, volume, and temperature for gases using the kinetic molecular model.	Particles in Action
<i>C2.2d Explain convection and the difference in transfer of thermal energy for solids, liquids, and gases using evidence that molecules are in constant motion.</i>	-
<i>C2.2e Compare the entropy of solids, liquids, and gases.</i>	-
<i>C2.2f Compare the average kinetic energy of the molecules in a metal object and a wood object at room temperature.</i>	-
C2.3x Breaking Chemical Bonds	
C2.3a Explain how the rate of a given chemical reaction is dependent on the temperature and the activation energy.	Bonds and Activation Energy Rates of Reaction Temperature and Reaction Rates
C2.3b Draw and analyze a diagram to show the activation energy for an exothermic reaction that is very slow at room temperature.	Bonds and Activation Energy Exothermic Reactions

C2.4x Electron Movement	
<i>C2.4a Describe energy changes in flame tests of common elements in terms of the (characteristic) electron transitions.</i>	–
C2.4b Contrast the mechanism of energy changes and the appearance of absorption and emission spectra.	Observing Line Spectra
C2.4c Explain why an atom can absorb only certain wavelengths of light.	Observing Line Spectra
C2.4d Compare various wavelengths of light (visible and nonvisible) in terms of frequency and relative energy.	–
C2.5x Nuclear Stability	
C2.5a Determine the age of materials using the ratio of stable and unstable isotopes of a particular type.	Radioactive Dating
C2.r5b Illustrate how elements can change in nuclear reactions using balanced equations.	Nuclear Fission Nuclear Fusion
<i>C2.r5c Describe the potential energy changes as two protons approach each other.</i>	–
<i>C2.r5d Describe how and where all the elements on Earth were formed.</i>	–
C3.1x Hess's Law	
C3.1a Calculate the enthalpy for a given reaction using Hess's Law.	Enthalpy Change
C3.1b Draw enthalpy diagrams for exothermic and endothermic reactions.	Enthalpy Change
C3.1c Calculate the enthalpy for a chemical reaction using simple coffee cup calorimetry.	Calorimetry
C3.1d Calculate the amount of heat produced for a given mass of reactant from a balanced chemical equation.	Enthalpy Change
C3.2x Enthalpy	
<i>C3.2a Describe the energy changes in photosynthesis and in the combustion of sugar in terms of bond breaking and bond making.</i>	–
<i>C3.2b Describe the relative strength of single, double, and triple covalent bonds between nitrogen atoms.</i>	–
C3.3 Heating Impacts	
<i>C3.3a Describe how heat is conducted in a solid.</i>	–
<i>C3.3b Describe melting on a molecular level.</i>	–
C3.3x Bond Energy	
C3.3c Explain why it is necessary for a molecule to absorb energy in order to break a chemical bond.	Bonds and Activation Energy
C3.4 Endothermic and Exothermic Reactions	
C3.4a Use the terms endothermic and exothermic correctly to describe chemical reactions in the laboratory.	Endothermic Reactions Exothermic Reactions

C3.4b Explain why chemical reactions will either release or absorb energy.	Bonds and Activation Energy Endothermic Reactions Exothermic Reactions
C3.4x Enthalpy and Entropy	
C3.4c Write chemical equations including the heat term as a part of equation or using enthalpy notation.	Enthalpy Change
C3.4d Draw enthalpy diagrams for reactants and products in endothermic and exothermic reactions.	Enthalpy Change
<i>C3.4e Predict if a chemical reaction is spontaneous given the enthalpy (ΔH) and entropy (ΔS) changes for the reaction using Gibb's Free Energy, $\Delta G = \Delta H - T\Delta S$ (Note: mathematical computation of ΔG is not required.)</i>	–
C3.4f Explain why some endothermic reactions are spontaneous at room temperature.	Endothermic Reactions
<i>C3.4g Explain why gases are less soluble in warm water than cold water.</i>	–
C3.5x Mass Defect	
C3.5a Explain why matter is not conserved in nuclear reactions.	Nuclear Fission Nuclear Fusion
C4.1x Molecular and Empirical Formulae	
C4.1a Calculate the percent by weight of each element in a compound based on the compound formula.	Percentage Composition by Mass
C4.1b Calculate the empirical formula of a compound based on the percent by weight of each element in the compound.	Types of Formulae
C4.1c Use the empirical formula and molecular weight of a compound to determine the molecular formula.	Types of Formulae
C4.2 Nomenclature	
C4.2a Name simple binary compounds using their formulae.	Naming Compounds
C4.2b Given the name, write the formula of simple binary compounds.	Naming Compounds Types of Formulae
C4.2x Nomenclature	
C4.2c Given a formula, name the compound.	Naming Compounds
C4.2d Given the name, write the formula of ionic and molecular compounds.	Naming Compounds Types of Formulae
C4.2e Given the formula for a simple hydrocarbon, draw and name the isomers.	Hydrocarbons Isomers
C4.3 Properties of Substances	

C4.3a Recognize that substances that are solid at room temperature have stronger attractive forces than liquids at room temperature, which have stronger attractive forces than gases at room temperature.	Intermolecular Forces
C4.3b Recognize that solids have a more ordered, regular arrangement of their particles than liquids and that liquids are more ordered than gases.	Intermolecular Forces Particles in Action
C4.3x Solids	
C4.3c Compare the relative strengths of forces between molecules based on the melting point and boiling point of the substances.	Intermolecular Forces
C4.3d Compare the strength of the forces of attraction between molecules of different elements. (For example, at room temperature, chlorine is a gas and iodine is a solid.)	Comparing Bonding Intermolecular Forces
C4.3e Predict whether the forces of attraction in a solid are primarily metallic, covalent, network covalent, or ionic based upon the elements' location on the periodic table.	Comparing Bonding Covalent Bonding Giant Covalent Structure Ionic Bonding Metallic Bonding Why do Atoms Form Bonds?
C4.3f Identify the elements necessary for hydrogen bonding (N, O, F).	Intermolecular Forces
C4.3g Given the structural formula of a compound, indicate all the intermolecular forces present (dispersion, dipolar, hydrogen bonding).	Intermolecular Forces
C4.3h Explain properties of various solids such as malleability, conductivity, and melting point in terms of the solid's structure and bonding.	Comparing Bonding Covalent Bonding Giant Covalent Structure Intermolecular Forces Ionic Bonding Metallic Bonding
C4.3i Explain why ionic solids have higher melting points than covalent solids. (For example, NaF has a melting point of 995°C, while water has a melting point of 0° C.)	Covalent Bonding Comparing Bonding Ionic Bonding
C4.4x Molecular Polarity	
<i>C4.4a Explain why at room temperature different compounds can exist in different phases.</i>	–
C4.4b Identify if a molecule is polar or nonpolar given a structural formula for the compound.	Electronegativity
C4.5x Ideal Gas Law	
C4.5a Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the pressure-volume relationship in gases.	Gases and Moles Ideal Gas Laws
C4.5b Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the pressure-temperature relationship in gases.	Gases and Moles Ideal Gas Laws

C4.5c Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the temperature-volume relationship in gases.	Gases and Moles Ideal Gas Laws
C4.6x Moles	
C4.6a Calculate the number of moles of any compound or element given the mass of the substance.	Molar Mass What are Moles?
C4.6b Calculate the number of particles of any compound or element given the mass of the substance.	What are Moles?
C4.7x Solutions	
<i>C4.7a Investigate the difference in the boiling point or freezing point of pure water and a salt solution.</i>	–
<i>C4.7b Compare the density of pure water to that of a sugar solution.</i>	–
C4.8 Atomic Structure	
C4.8a Identify the location, relative mass, and charge for electrons, protons, and neutrons.	Atomic Structure
C4.8b Describe the atom as mostly empty space with an extremely small, dense nucleus consisting of the protons and neutrons and an electron cloud surrounding the nucleus.	Atomic Structure Introducing Atoms
C4.8c Recognize that protons repel each other and that a strong force needs to be present to keep the nucleus intact.	Atomic Structure Nuclear Fission
C4.8d Give the number of electrons and protons present if the fluoride ion has a -1 charge.	Atomic Number and Atomic Mass Formation of Ions
C4.8x Electron Configuration	
C4.8e Write the complete electron configuration of elements in the first four rows of the periodic table.	Electron Configuration
C4.8f Write kernel structures for main group elements.	Atomic Number and Mass Number
C4.8g Predict oxidation states and bonding capacity for main group elements using their electron structure.	Electron Configuration Electron Structure Oxidation Numbers
C4.8h Describe the shape and orientation of s and p orbitals.	Orbitals
C4.8i Describe the fact that the electron location cannot be exactly determined at any given time.	Orbitals
C4.9 Periodic Table	
C4.9a Identify elements with similar chemical and physical properties using the periodic table.	Electron Structure and the Periodic Table The Noble Gases The Periodic Table
C4.9x Electron Energy Levels	
C4.9b Identify metals, non-metals, and metalloids using the periodic table.	The Periodic Table

C4.9c Predict general trends in atomic radius, first ionization energy, and electronegativity of the elements using the periodic table.	Electron Structure and the Periodic Table Electronegativity Ionization Energy
C4.10 Neutral Atoms, Ions, and Isotopes	
C4.10a List the number of protons, neutrons, and electrons for any given ion or isotope.	Atomic Number and Atomic Mass Electron Structure and the Periodic Table Formation of Ions Isotopes
C4.10b Recognize that an element always contains the same number of protons.	Atomic Number and Atomic Mass
C4.10x Average Atomic Mass	
C4.10c Calculate the average atomic mass of an element given the percent abundance and mass of the individual isotopes.	Atomic Number and Atomic Mass Isotopes
C4.10d Predict which isotope will have the greatest abundance given the possible isotopes for an element and the average atomic mass in the periodic table.	Isotopes
C4.10e Write the symbol for an isotope, X_Z^A , where Z is the atomic number, A is the mass number, and X is the symbol for the element.	Atomic Number and Atomic Mass Isotopes
C5.1x Rates of Reactions (recommended)	
C5.1a Predict how the rate of a chemical reaction will be influenced by changes in concentration, and temperature, pressure. (recommended)	Concentration, Pressure and Reaction Rates Rates of Reaction Temperature and Reaction Rates
C5.1b Explain how the rate of a reaction will depend on concentration, temperature, pressure, and nature of reactant. (recommended)	Concentration, Pressure and Reaction Rates Rates of Reaction Surface Area and Catalysts Temperature and Reaction Rates
C5.2 Chemical Changes	
C5.2a Balance simple chemical equations applying the conservation of matter.	Conservation of Mass
<i>C5.2b Distinguish between chemical and physical changes in terms of the properties of the reactants and products.</i>	–
<i>C5.2C Draw pictures to distinguish the relationships between atoms in physical and chemical changes.</i>	–
C5.2x Balancing Equations	
C5.2d Calculate the mass of a particular compound formed from the masses of starting materials.	Reacting Masses
<i>C5.2e Identify the limiting reagent when given the masses of more than one reactant.</i>	–

C5.2f Predict volumes of product gases using initial volumes of gases at the same temperature and pressure.	Gases and Moles Ideal Gas Laws
C5.2g Calculate the number of atoms present in a given mass of element.	What are Moles?
C5.3x Equilibrium	
C5.3a Describe equilibrium shifts in a chemical system caused by changing conditions (Le Chatelier's Principle).	Le Chatelier's Principle
C5.3b Predict shifts in a chemical system caused by changing conditions (Le Chatelier's Principle).	Le Chatelier's Principle
C5.3c Predict the extent reactants are converted to products using the value of the equilibrium constant.	Le Chatelier's Principle The Haber Process
C5.4 Phase Change/ Diagrams	
<i>C5.4a Compare the energy required to raise the temperature of one gram of aluminum and one gram of water the same number of degrees.</i>	–
C5.4b Measure, plot, and interpret the graph of the temperature versus time of an ice-water mixture, under slow heating, through melting and boiling.	Changing State
C5.4x Changes of State	
C5.4c Explain why both the melting point and boiling points for water are significantly higher than other small molecules of comparable mass (e.g. ammonia and methane).	Water
C5.4d Explain why freezing is an exothermic change of state.	Exothermic Reactions Intermolecular Forces
C5.4e Compare the melting point of covalent compounds based on the strength of IMFs (intermolecular forces).	Covalent Bonding Giant Covalent Structures Intermolecular Forces
C5.5 Chemical Bonds — Trends	
C5.5a Predict if the bonding between two atoms of different elements will be primarily ionic or covalent.	Comparing Bonding Covalent Bonding Ionic Compounds
C5.5b Predict the formula for binary compounds of main group elements.	Types of Formulae
C5.5x Chemical Bonds	
<i>C5.5c Draw Lewis structures for simple compounds.</i>	–
C5.5d Compare the relative melting point, electrical and thermal conductivity and hardness for ionic, metallic, and covalent compounds.	Comparing Bonding Covalent Bonding Ionic Bonding Ionic Compounds Metallic Bonding

C5.5e Relate the melting point, hardness, and electrical and thermal conductivity of a substance to its structure.	Comparing Bonding Covalent Bonding Giant Covalent Structures Ionic Compounds Metallic Bonding
C5.6x Reduction/Oxidation Reactions	
C5.6a Balance half-reactions and describe them as oxidations or reductions.	Redox Reactions
C5.6b Predict single replacement reactions.	Redox Reactions
C5.6c <i>Explain oxidation occurring when two different metals are in contact.</i>	–
C5.6d <i>Calculate the voltage for spontaneous redox reactions from the standard reduction potentials.</i>	–
C5.6e Identify the reactions occurring at the anode and cathode in an electrochemical cell.	Electrolysis of Lead Bromide Electrolysis NaCl Electrolysis of Dilute Sulfuric Acid Extraction Aluminum Purification of Copper
C5.7 Acids and Bases	
C5.7a Recognize formulas for common inorganic acids, carboxylic acids, and bases formed from families I and II.	Carboxylic Acids
C5.7b Predict products of an acid-base neutralization.	Neutralization
C5.7c Describe tests that can be used to distinguish an acid from a base.	pH and Indicators
C5.7d Classify various solutions as acidic or basic, given their pH.	pH and Indicators Properties of Acids and Alkalis
C5.7e <i>Explain why lakes with limestone or calcium carbonate experience less adverse effects from acid rain than lakes with granite beds.</i>	–
C5.7x Brønsted-Lowry	
C5.7f Write balanced chemical equations for reactions between acids and bases and perform calculations with balanced equations.	Neutralization
C5.7g <i>Calculate the pH from the hydronium ion or hydroxide ion concentration.</i>	–
C5.7h Explain why sulfur oxides and nitrogen oxides contribute to acid rain.	–
C5.7i <i>Identify the Brønsted-Lowry conjugate acid-base pairs in an equation. (recommended)</i>	–
C5.8 Carbon Chemistry	
C5.8a Draw structural formulas for up to ten carbon chains of simple hydrocarbons.	Hydrocarbons
C5.8b Draw isomers for simple hydrocarbons.	Hydrocarbons Isomers

C5.8c Recognize that proteins, starches, and other large biological molecules are polymers.

Nucleic Acids
Polymers
Polysaccharides
Proteins