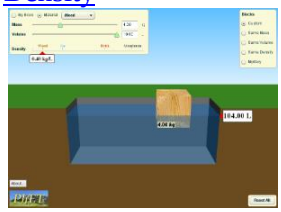
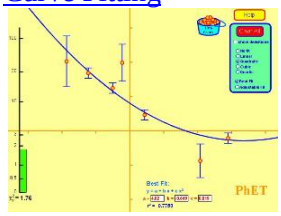
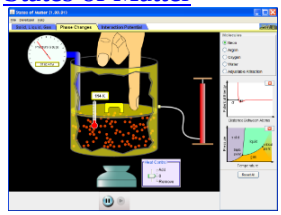
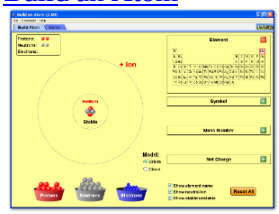
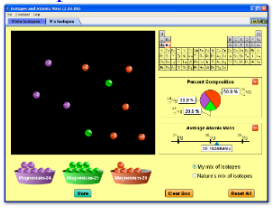
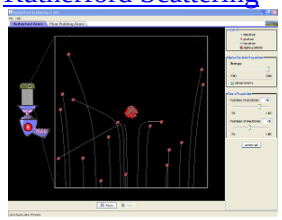
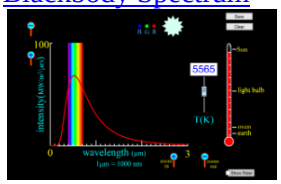
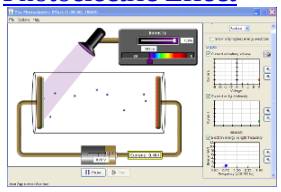
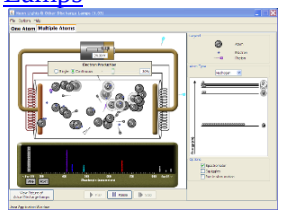
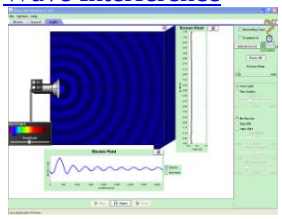
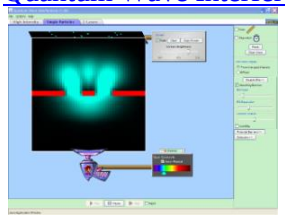
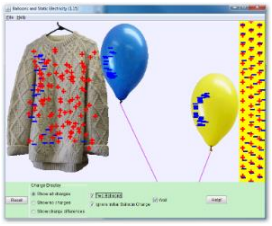
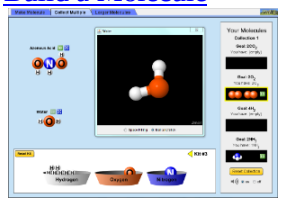
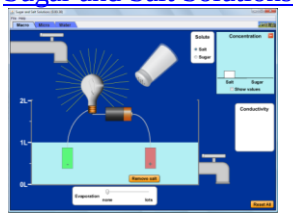
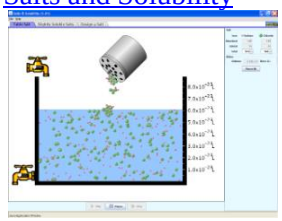
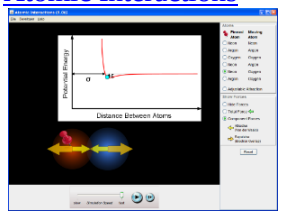
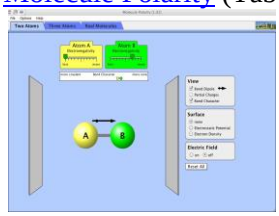
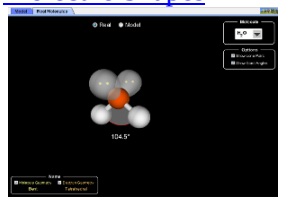
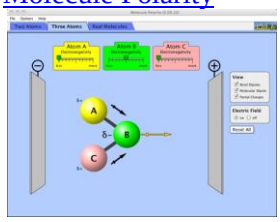
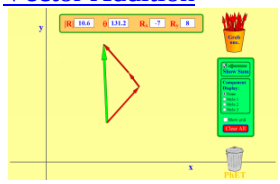
PhET Interactive Chemistry Simulations
Aligned to an Example General Chemistry Curriculum

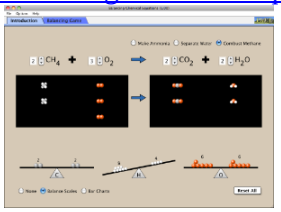
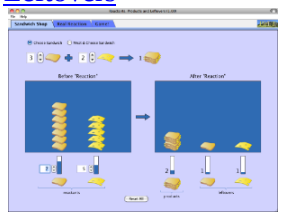
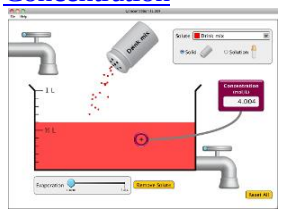
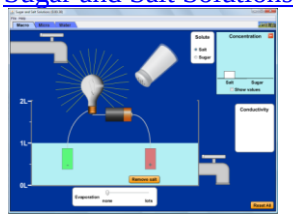
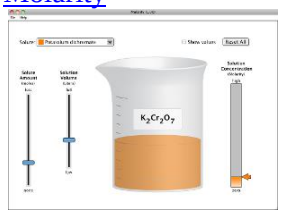
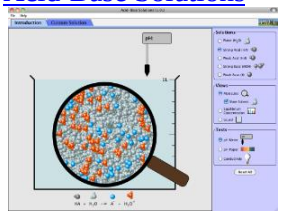
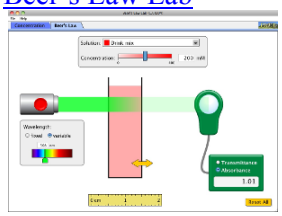
Alignment is based on the topics and subtopics addressed by each sim. Sims that directly address the topic area are in the middle column; sims that relate to the topic area are in the "supplemental" column.

Topic Areas and Sub-topics	PhET Simulations	Supplemental PhET Simulations
Measurement, Significant Figures, and Uncertainty	Density  – Measurement and unit conversions	Curve Fitting  – Measurement and uncertainty
Properties of Matter – Phases of matter, mixtures and pure substances, chemical and physical change, temperature as a measure of average kinetic energy	States of Matter  – Phases of matter, physical change	Density (above) – Properties of matter: density, mass, volume Gas Properties  – Temperature as a measure of average kinetic energy
Components of Matter: Atoms and Isotopes – Atomic number, mass number, atomic symbol, atomic mass, isotopes, isotopic abundance – Atomic masses; determination by chemical and physical means	Build an Atom  – Atomic number, mass number, atomic symbol, protons, neutrons, and electrons Isotopes and Atomic Mass  – Atomic number, mass number, atomic symbol, atomic mass, isotopes, isotopic abundance	

Development of the Atomic View of Matter / Evidence for the Atomic Theory – Dalton's atomic theory, discovery of the electron (Millikan and Thompson), discovery of the atomic nucleus (Rutherford)	Rutherford Scattering  – Discovery of the atomic nucleus (Rutherford)	
Atomic Structure of Matter and Quantum Theory – Electromagnetic spectrum, interference, blackbody radiation, photoelectric effect, Rydberg Equation, Bohr model, atomic line spectra, wave-particle duality, de Broglie wavelength, Heisenberg's uncertainty principle, Schrodinger equation, atomic orbitals, quantum numbers and energy levels	Blackbody Spectrum  – Electromagnetic spectrum, blackbody radiation Photoelectric Effect  – Electromagnetic spectrum, photoelectric effect Models of the Hydrogen Atom  – Electromagnetic spectrum, Rydberg Equation, Bohr model, atomic line spectra, wave-particle duality, Schrodinger equation, atomic orbitals, quantum numbers and energy levels	Neon Lights and Other Discharge Lamps  Atomic line spectra, atomic orbitals, quantum numbers and energy levels Wave Interference  – Electromagnetic spectrum, interference Quantum Wave Interference  – Electromagnetic spectrum, interference, wave-particle duality, de Broglie wavelength

Electron Configuration and Periodic Trends – Pauli exclusion, Aufbau principle, and Hund's rule; electron configuration; orbital diagram; shielding; periodic trends (atomic size, ionization energy, electron affinity); periodic trends (electronegativity, metallic behavior, ion size)		Build an Atom (above) – Periodic trends (atomic number, number of electrons) Neon Lights and Other Discharge Lamps (above) – Ionization energy Balloons and Static Electricity  – Electrostatic attractions, effective nuclear charge, electron affinity
Components of Matter: Elements and Compounds – Periodic table, metals, nonmetals, metalloids, molecules from atoms, general bonding, ionic and covalent bonding, formulas, molecular mass, molecular models, mixtures and pure substances	Build a Molecule  – Periodic table, molecules from atoms, covalent bonding, formulas, molecular models	Sugar and Salt Solutions  – Ionic and covalent bonding, formulas, mixtures and pure substances
Nomenclature – Binary ionic compounds, binary covalent compounds, polyatomic ions, oxoanions, hydrates, acids and bases, organic molecules		Sugar and Salt Solutions (above) – Binary ionic compounds, polyatomic ions Salts and Solubility  – Binary ionic compounds, polyatomic ions

Chemical Bonding – Lewis dot structures, octet rule; ionic bonding model, covalent bonding model; covalent bond order, bond length, lone pairs; electronegativity and bond polarity, partial ionic character, metallic bonding (electron sea model) – Binding forces (types; relationships to states, structure, properties; polarity and electronegativity)	Atomic Interactions  – Covalent bonding model, binding forces	Molecule Polarity (Tab 1)  – Electronegativity and bond polarity, partial ionic character, partial covalent character – Binding forces (polarity and electronegativity)
Molecular Geometry and Polarity, Molecular Structure, Molecular Models – Lewis dot structures and geometry, resonance, formal charge, VSEPR, shape and molecule polarity – Geometry of molecules and ions, orbital hybridization, dipole moments of molecules; relation of properties to structure	Molecule Shapes  – Geometry of molecules, VSEPR Molecule Polarity  – Shape and molecule polarity – Dipole moments of molecules; relation of properties to structure	Build a Molecule (above) (Tab 3) – Geometry of molecules Vector Addition  – Bond dipoles and molecular dipoles (polarity supplement)
Organic Compounds – Nomenclature, structures, hydrocarbons, alkanes, functional groups, structural isomerism of simple organic molecules		Build a Molecule (above) – Geometry of small organic molecules

Chemical Equations and Stoichiometry – The mole and molar mass, amount-mass-number conversions, mass percent, empirical formula/combustion analysis, balancing chemical equations, limiting reactants, theoretical and actual percent yields, aqueous ionic reactions – Conservations of mass	Balancing Chemical Equations  – Balancing chemical equations, mole ratios, conservation of mass Reactants, Products and Leftovers  – Balancing chemical equations, limiting reactants, mole ratios, conservations of mass	
Chemical Reactions and Solutions – Dissociation, strong and weak electrolytes, polyprotic acids, titrations, precipitation reactions, acid-base reactions, redox reactions, solution concentration and units of molarity	Concentration  – Solution concentration and units of molarity Sugar and Salt Solutions  – Dissociation, strong and weak electrolytes, solution concentration	Molarity  – Solution concentration and units of molarity Acid-Base Solutions  – Acid-base reactions, dissociation, strong and weak electrolytes, solution concentration Beer's Law Lab  – Solution concentration and units of molarity

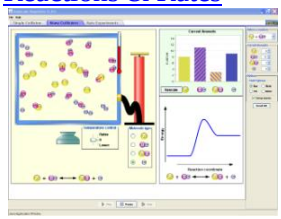
Thermochemistry

- Energy, heat and work, 1st law of thermodynamics, state functions and path functions, enthalpy, endothermic and exothermic processes, heat capacity, calorimetry, thermochemical stoichiometry, Hess' law, standard enthalpies of reaction
- Endothermic and exothermic physical processes, bond dissociation energy

Energy Forms and Changes

- Energy, heat, and work, endothermic and exothermic processes, heat capacity

Reactions & Rates

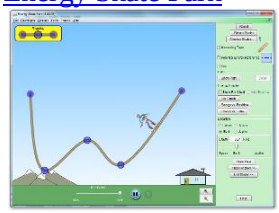


- Endothermic and exothermic chemical processes

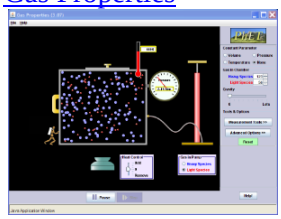
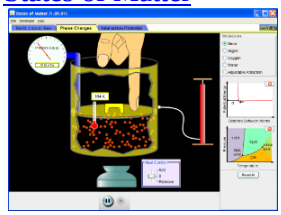
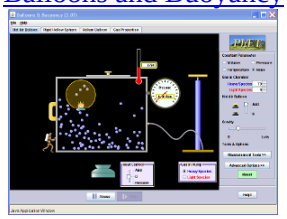
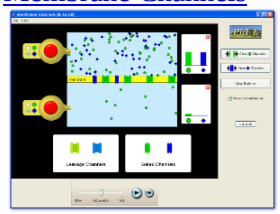
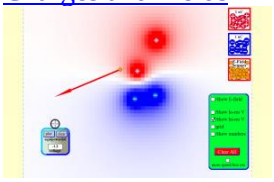
Molecules and Light

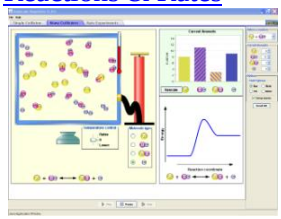
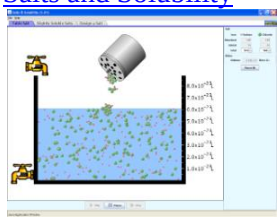
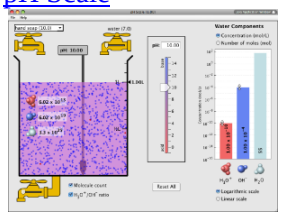
- Bond dissociation energy, endothermic chemical processes, chemical bonds

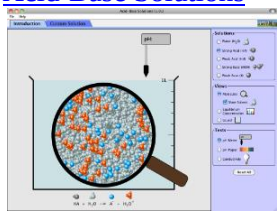
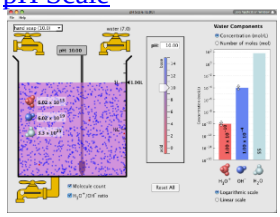
Energy Skate Park



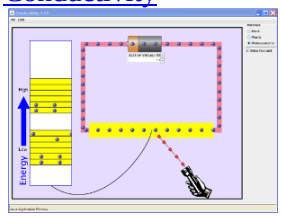
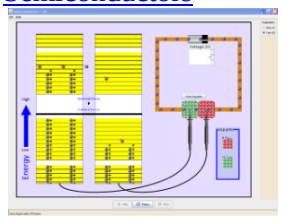
- Energy, 1st law of thermodynamics,

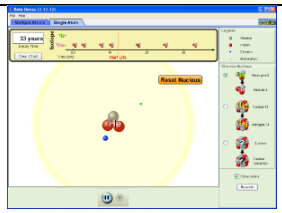
Gases – States of matter, gas laws, partial pressure, gas stoichiometry, kinetic-molecular theory, RMS speed, effusion and diffusion, mean free path/collision frequency, real gases	Gas Properties  – Gas laws, partial pressure, kinetic-molecular theory RMS speed, mean free path/collision frequency States of Matter  – Real gases, states of matter –	Balloons and Buoyancy  – States of matter, gas laws, partial pressure, gas stoichiometry, kinetic-molecular theory of gases, RMS speed, effusion and diffusion, mean free path/collision frequency, real gases Membrane Channels  – Effusion and diffusion
Intermolecular Forces – Dipole-dipole interactions, hydrogen bonding, dispersion forces, consequences for properties of matter (vapor pressure and boiling points)		Sugar and Salt Solutions (above) – Hydrogen bonding, dipole-dipole interactions States of Matter (above) – Hydrogen bonding, dispersion forces, consequences for properties of matter Charges and Fields  – Dipole-dipole interactions, dispersion forces, electrostatic attractions Balloons and Static Electricity (above) Electrostatic attractions, dispersion forces

Chemical Kinetics, Reactions, and Rates – Reactions and rates, rate laws, integrated rate laws, temperature and activation energy, reaction mechanisms, catalysis – Collision theory, reaction rates, factors influencing reaction rate	Reactions & Rates  – Reactions and rates, kinematics, temperature and activation energy, collision theory, factors influencing reaction rates Reversible Reactions  – Reaction rates, temperature and activation energy, factors influencing reaction rates	
Equilibrium – Concept of dynamic equilibrium, reversibility of reactions, equilibrium expressions – Quantitative treatment: equilibrium constants of gas phase reactions, equilibrium constants for reactions in solution – Le Chatelier's principle, reaction quotient (Q vs. K), effect of temperature and pressure on equilibrium	Salts and Solubility  – Concept of dynamic equilibrium, reversibility of reactions – Quantitative treatment, equilibrium constants for reactions in solution – Le Chatelier's principle Reactions & Rates (above) – Concept of dynamic equilibrium: reversibility of reactions – Le Chatelier's principle, effect of temperature and pressure on equilibrium	pH Scale  – Concept of dynamic equilibrium, reversibility of reactions Acid-Base Solutions (above) – Concept of dynamic equilibrium: reversibility of reactions

Acids, Bases, and Acid-Base Equilibria – Acids and bases, proton transfer reactions, autoionization and the pH scale, weak acids and bases, equilibrium calculations, molecular properties and acid strength, acid-base properties of salts – Arrhenius acids and bases, hydrogen ions, hydroxide ions, Bronsted-Lowry acids and bases, hydronium ions, concentration, acid-base reactions, buffering, Le Chatelier's principle	Acid-Base Solutions  – Acids and bases, proton transfer reactions, autoionization and the pH scale, weak acids and bases, equilibrium calculations, molecular properties and acid strength, acid-base properties of salts – Arrhenius acids and bases, hydrogen ions, hydroxide ions, Bronsted-Lowry acids and bases, hydronium ions, concentration pH Scale  – Acids and bases, proton transfer reactions, autoionization and the pH scale, weak acids and bases, equilibrium calculations, molecular properties and acid strength – Arrhenius acids and bases, hydrogen ions, hydroxide ions, Bronsted-Lowry acids and bases, hydronium ions, concentration	
Solubility Equilibria Liquid state, solutions, ionic bonds, ions, complex ions, solubility, diffusion, osmosis	Salts and Solubility (above) – Liquid state, solutions, ionic bonds, ions, complex ions, solubility, diffusion Sugar and Salt Solutions (above) Solutions, ionic bonds, ions, complex ions, solubility	Beer's Law Lab (above) – Solutions, solubility Membrane Channels (above) Diffusion, osmosis

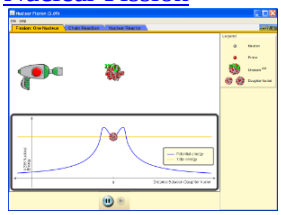
Buffers and Titrations – Qualitative and quantitative aspects of buffers, capacity and range, titrations, acid-base indicators		
Entropy and the Second Law of Thermodynamics – Concept of a "spontaneous" process, entropy, the 2nd law of thermodynamics, entropy and probability, Gibbs Energy ("Gibbs Free Energy"), connection to equilibrium.		Reversible Reactions (above) – Concept of a "spontaneous" process, entropy, the 2nd law of thermodynamics, entropy and probability, Gibbs Energy ("Gibbs Free Energy"), connection to equilibrium.
Oxidation-Reduction Reactions and Electrochemistry – Oxidation/reduction reactions, electrochemical cells, standard cell potentials, Gibbs energy and electrical work, batteries and corrosion, electrolysis… – Voltaic cell, oxidation-reduction reactions, electrochemical reaction, current, voltage, electrodes, half-reactions, fuel cells, efficiency		

Transition Metals and Coordination Compounds – Chemistry of the transition metals, coordination compounds, geometric structures of coordination compounds and optical isomers, crystal field theory, coordination compounds in biology – Solid state, alloys, metals, crystals, manipulation of physical structure to achieve specific properties, mole concept		Molecule Shapes (above) – Geometric structures of coordination compounds and optical isomers Beer's Law Lab (above) – Chemistry of the transition metals Conductivity  – Solid state, metals, manipulation of physical structure to achieve specific properties Semiconductors  – Solid state, metals, manipulation of physical structure to achieve specific properties
Nuclear Chemistry – Nuclear equations, half-lives, radioactivity, isotopes, radioactive decay series, band of stability – The atomic nucleus and radioactivity, kinetics of radioactive decay – Alpha particles, beta particles, gamma rays, alpha decay, beta decay – Nuclear fusion, nuclear fission, nuclear strong force – Chemical applications, biological effects of radiation	Alpha Decay  – Nuclear equations, half-lives, radioactivity, isotopes, radioactive decay series – The atomic nucleus and radioactivity, kinetics of radioactive decay – Alpha particles, alpha decay, nuclear strong force Beta Decay	



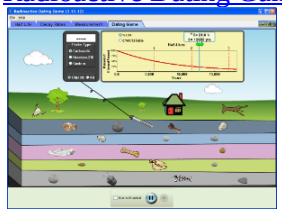
- Nuclear equations, half-lives, radioactivity, isotopes, radioactive decay series
- The atomic nucleus and radioactivity, kinetics of radioactive decay
- Beta particles, beta decay, nuclear strong force

Nuclear Fission



- Radioactivity, isotopes
- The atomic nucleus and radioactivity, kinetics of radioactive decay
- Nuclear fission, nuclear strong force
- Chemical applications, nuclear reactor

Radioactive Dating Game



- Nuclear equations, half-lives, radioactivity, isotopes, radioactive decay series
- The atomic nucleus and radioactivity, kinetics of radioactive decay
- Chemical applications

Light and Matter Interactions and Spectroscopy

- Topic may be discussed throughout the curriculum.

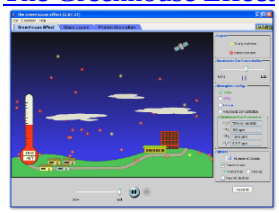
Models of the Hydrogen Atom (above)

- Line emission spectrum
- Electromagnetic spectrum

Beer's Law Lab (above)

- Absorbance, transmittance, molar absorptivity
- Visible spectrum

The Greenhouse Effect

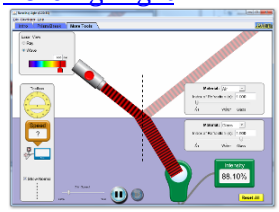


- Environmental chemistry
- Rotational, vibrational, and emission spectroscopy, bond energy, electromagnetic spectrum

Molecules and Light

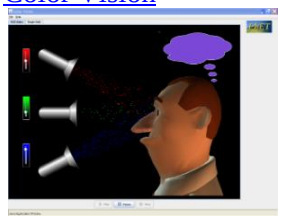
- Environmental chemistry
- Rotational, vibrational, and emission spectroscopy, bond energy, electromagnetic spectrum

Bending Light



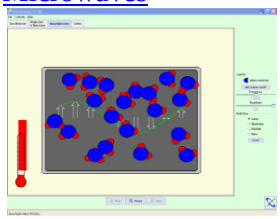
- Diffraction, refraction, reflection

Color Vision



- Electromagnetic spectrum
- Visible spectrum

Microwaves



- Polarity, intermolecular forces, rotational spectroscopy, temperature