**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.

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| **Topic Areas and**  **Sub-topics** | **PhET Simulations** | **Supplemental PhET Simulations** |
| **Measurement, Significant Figures, and Uncertainty** | [Density](http://phet.colorado.edu/en/simulation/density)     * Measurement and unit conversions | [Curve Fitting](http://phet.colorado.edu/en/simulation/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](http://phet.colorado.edu/en/simulation/states-of-matter)     * Phases of matter, physical change | [Density](http://phet.colorado.edu/en/simulation/density) (above)   * Properties of matter: density, mass, volume   [Gas Properties](http://phet.colorado.edu/en/simulation/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](http://phet.colorado.edu/en/simulation/build-an-atom)     * Atomic number, mass number, atomic symbol, protons, neutrons, and electrons   [Isotopes and Atomic Mass](http://phet.colorado.edu/en/simulation/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](http://phet.colorado.edu/en/simulation/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](http://phet.colorado.edu/en/simulation/blackbody-spectrum)     * Electromagnetic spectrum, blackbody radiation   [Photoelectric Effect](http://phet.colorado.edu/en/simulation/photoelectric)     * Electromagnetic spectrum, photoelectric effect   [Models of the Hydrogen Atom](http://phet.colorado.edu/en/simulation/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](http://phet.colorado.edu/en/simulation/discharge-lamps)     * Atomic line spectra, atomic orbitals, quantum numbers and energy levels   [Wave Interference](http://phet.colorado.edu/en/simulation/wave-interference)     * Electromagnetic spectrum, interference   [Quantum Wave Interference](http://phet.colorado.edu/en/simulation/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](http://phet.colorado.edu/en/simulation/build-an-atom) (above)   * Periodic trends (atomic number, number of electrons)   [Neon Lights and Other Discharge Lamps](http://phet.colorado.edu/en/simulation/discharge-lamps) (above)   * Ionization energy   [Balloons and Static Electricity](http://phet.colorado.edu/en/simulation/balloons)     * 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](http://phet.colorado.edu/en/simulation/build-a-molecule)     * Periodic table, molecules from atoms, covalent bonding, formulas, molecular models | [Sugar and Salt Solutions](http://phet.colorado.edu/en/simulation/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](http://phet.colorado.edu/en/simulation/sugar-and-salt-solutions) (above)   * Binary ionic compounds, polyatomic ions   [Salts and Solubility](http://phet.colorado.edu/en/simulation/soluble-salts)     * 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](http://phet.colorado.edu/en/simulation/atomic-interactions)     * Covalent bonding model, binding forces | [Molecule Polarity](http://phet.colorado.edu/en/simulation/molecule-polarity) (Tab 1)  screenshot_104   * 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](http://phet.colorado.edu/en/simulation/molecule-shapes)     * Geometry of molecules, VSEPR   [Molecule Polarity](http://phet.colorado.edu/en/simulation/molecule-polarity)     * Shape and molecule polarity * Dipole moments of molecules; relation of properties to structure | [Build a Molecule](http://phet.colorado.edu/en/simulation/build-a-molecule) (above) (Tab 3)   * Geometry of molecules   [Vector Addition](http://phet.colorado.edu/en/simulation/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](http://phet.colorado.edu/en/simulation/build-a-molecule) (above)   * Geometry of small organic molecules |

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| **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](http://phet.colorado.edu/en/simulation/balancing-chemical-equations)     * Balancing chemical equations, mole ratios, conservation of mass   [Reactants, Products and Leftovers](http://phet.colorado.edu/en/simulation/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](http://phet.colorado.edu/en/simulation/concentration)     * Solution concentration and units of molarity   [Sugar and Salt Solutions](http://phet.colorado.edu/en/simulation/sugar-and-salt-solutions)     * Dissociation, strong and weak electrolytes, solution concentration | [Molarity](http://phet.colorado.edu/en/simulation/molarity)     * Solution concentration and units of molarity   [Acid-Base Solutions](http://phet.colorado.edu/en/simulation/acid-base-solutions)     * Acid-base reactions, dissociation, strong and weak electrolytes, solution concentration   [Beer’s Law Lab](http://phet.colorado.edu/en/simulation/beers-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](http://phet.colorado.edu/en/simulation/energy-forms-and-changes)     * Energy, heat, and work, endothermic and exothermic processes, heat capacity | [Reactions & Rates](http://phet.colorado.edu/en/simulation/reactions-and-rates)     * Endothermic and exothermic chemical processes   [Molecules and Light](http://phet.colorado.edu/en/simulation/molecules-and-light)     * Bond dissociation energy, endothermic chemical processes, chemical bonds   [Energy Skate Park](http://phet.colorado.edu/en/simulation/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](http://phet.colorado.edu/en/simulation/gas-properties)     * Gas laws, partial pressure, kinetic-molecular theory RMS speed, mean free path/collision frequency   [States of Matter](http://phet.colorado.edu/en/simulation/states-of-matter)     * Real gases, states of matter | [Balloons and Buoyancy](http://phet.colorado.edu/en/simulation/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](http://phet.colorado.edu/en/simulation/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](http://phet.colorado.edu/en/simulation/sugar-and-salt-solutions) (above)   * Hydrogen bonding, dipole-dipole interactions   [States of Matter](http://phet.colorado.edu/en/simulation/states-of-matter) (above)   * Hydrogen bonding, dispersion forces, consequences for properties of matter   [Charges and Fields](http://phet.colorado.edu/en/simulation/charges-and-fields)     * Dipole-dipole interactions, dispersion forces, electrostatic attractions   [Balloons and Static Electricity](http://phet.colorado.edu/en/simulation/balloons)(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](http://phet.colorado.edu/en/simulation/reactions-and-rates)     * Reactions and rates, kinematics, temperature and activation energy, collision theory, factors influencing reaction rates   [Reversible Reactions](http://phet.colorado.edu/en/simulation/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](http://phet.colorado.edu/en/simulation/soluble-salts)     * Concept of dynamic equilibrium, reversibility of reactions * Quantitative treatment, equilibrium constants for reactions in solution * Le Chatelier's principle   [Reactions & Rates](http://phet.colorado.edu/en/simulation/reactions-and-rates) (above)   * Concept of dynamic equilibrium: reversibility of reactions * Le Chatelier's principle, effect of temperature and pressure on equilibrium | [pH Scale](http://phet.colorado.edu/en/simulation/ph-scale)     * Concept of dynamic equilibrium, reversibility of reactions   [Acid-Base Solutions](http://phet.colorado.edu/en/simulation/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](http://phet.colorado.edu/en/simulation/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 |  |

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| **Acids, Bases, and Acid-Base Equilibria, continued.** | [pH Scale](http://phet.colorado.edu/en/simulation/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](http://phet.colorado.edu/en/simulation/soluble-salts) (above)   * Liquid state, solutions, ionic bonds, ions, complex ions, solubility, diffusion   [Sugar and Salt Solutions](http://phet.colorado.edu/en/simulation/sugar-and-salt-solutions) (above)   * Solutions, ionic bonds, ions, complex ions, solubility | [Beer’s Law Lab](http://phet.colorado.edu/en/simulation/beers-law-lab) (above)   * Solutions, solubility   [Membrane Channels](http://phet.colorado.edu/en/simulation/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](http://phet.colorado.edu/en/simulation/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](http://phet.colorado.edu/en/simulation/molecule-shapes) (above)   * Geometric structures of coordination compounds and optical isomers   [Beer’s Law Lab](http://phet.colorado.edu/en/simulation/beers-law-lab) (above)   * Chemistry of the transition metals   [Conductivity](http://phet.colorado.edu/en/simulation/conductivity)     * Solid state, metals, manipulation of physical structure to achieve specific properties   [Semiconductors](http://phet.colorado.edu/en/simulation/semiconductor)     * Solid state, metals, manipulation of physical structure to achieve specific properties |

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| **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](http://phet.colorado.edu/en/simulation/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](http://phet.colorado.edu/en/simulation/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](http://phet.colorado.edu/en/simulation/nuclear-fission)   * Radioactivity, isotopes * The atomic nucleus and radioactivity, kinetics of radioactive decay * Nuclear fission, nuclear strong force * Chemical applications, nuclear reactor |  |

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| **Nuclear Chemistry, continued.** | [Radioactive Dating Game](http://phet.colorado.edu/en/simulation/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](http://phet.colorado.edu/en/simulation/hydrogen-atom) (above)   * Line emission spectrum * Electromagnetic spectrum   [Beer’s Law Lab](http://phet.colorado.edu/en/simulation/beers-law-lab) (above)   * Absorbance, transmittance, molar absorptivity * Visible spectrum   [The Greenhouse Effect](http://phet.colorado.edu/en/simulation/greenhouse)     * Environmental chemistry * Rotational, vibrational, and emission spectroscopy, bond energy, electromagnetic spectrum   [Molecules and Light](http://phet.colorado.edu/en/simulation/molecules-and-light)     * Environmental chemistry * Rotational, vibrational, and emission spectroscopy, bond energy, electromagnetic spectrum | [Bending Light](http://phet.colorado.edu/en/simulation/bending-light)     * Diffraction, refraction, reflection   [Color Vision](http://phet.colorado.edu/en/simulation/color-vision)     * Electromagnetic spectrum * Visible spectrum   [Microwaves](http://phet.colorado.edu/en/simulation/microwaves)     * Polarity, intermolecular forces, rotational spectroscopy, temperature |