The 6 Big Ideas and 117 Learning Objectives of the AP® Chemistry Curriculum Framework

Big Idea 1. All matter is composed of atoms.

Learning Objectives

1.1 Justify that the elemental mass ratio in any pure compound is always identical using atomic molecular theory.
1.2 Identify or infer from mass data the quantitative compositions of pure substances and mixtures.
1.3 Use calculations of mass data to determine the identity or purity of a substance.
1.4 Interconvert quantities of substances: number of particles, moles, masses, and volumes.
1.5 Use data to explain electron distributions in atoms or ions.
1.6 Analyze data of electron energies for patterns and relationships.
1.7 Describe atomic electronic structure using Coulomb's law, ionization energy, and data from photoelectron spectroscopy.
1.8 Analyze measured energies to explain electron configurations using Coulomb's law.
1.9 Predict atomic properties and explain their trends using the shell model and atomic placement on the periodic table.
1.10 Use experimental evidence to explain the arrangement of the periodic table and apply periodic properties to chemical reactivity.
1.11 Analyze and identify patterns in data for binary compounds to predict properties of related compounds.
1.12 Explain how data sets support the classical shell atomic model or the quantum mechanical model.
1.13 Justify that an atomic model is consistent with a given set of data.
1.14 Use mass spectral data to identify elements and the masses of isotopes.
1.15 Explain why different types of spectroscopy are used to measure vibration and electronic motions of molecules.
1.16 Design and interpret an experiment that uses spectrophotometry to determine the concentration of a substance in solution.
1.17 Use both symbols and particle drawings in balanced chemical equations to quantitatively and qualitatively express the law of conservation of mass.
1.18 Apply conservation of atoms to particle views of balanced chemical reactions and physical changes.
1.19 Design and interpret data from a gravimetric analysis experiment to determine the concentration of a substance in solution.
1.20 Design and interpret data from a titration experiment to determine the concentration of a substance in solution.

Big Idea 3. Chemical reactions involve the rearrangement of Atoms and describe how matter changes.

Learning Objectives

3.1 Interpret macroscopic observations of change using symbols, chemical equations, and particle views.
3.2 Interpret an observed chemical change using a balanced molecular (complete), ionic, or net ionic equation and justify why each is used in a given situation.
3.3 Use stoichiometry calculations to model laboratory chemical reactions and analyze deviations from the expected results.
3.4 Apply stoichiometry calculations to convert measured quantities such as masses, solution volumes, or volumes and pressures of gases to other quantities in chemical reactions, including reactions with limiting reactants or unreacted products.
3.5 Design an experiment and analyze its data for the synthesis or decomposition of a compound to confirm the conservation of mass and the law of definite proportions.
3.6 Use data from synthesis or decomposition of a compound to confirm the conservation of mass and the law of definite proportions.
3.7 Use proton-transfer reactions to identify compounds such as Brønsted–Lowry acids and bases and conjugate acid–base pairs.
3.8 Use electron transfer to identify redox reactions.
3.9 Design or interpret the results of a redox titration experiment.
3.10 Classify a process as a physical change, a chemical change, or an ambiguous change using macroscopic observations and the formation or breaking of chemical bonds or intermolecular forces.
3.11 Create symbolic and graphical representations to describe energy changes associated with a chemical or physical change.
3.12 Use half-cell reactions, potentials, and Faraday's laws to make quantitative predictions about voltaic (galvanic) or electrolytic reactions.

Big Idea 2. Chemical bonding and intermolecular forces explain the chemical and physical properties of matter.

Learning Objectives

2.1 Predict properties based on chemical formulas and explain properties using particle views.
2.2 Explain the relative strengths of acids and bases using molecular structure, intermolecular forces, and solution equilibrium.
2.3 Use particulate models and energy considerations to explain the differences between solids and liquids.
2.4 Use kinetic molecular theory and intermolecular forces to predict and explain the macroscopic properties of real and ideal gases.
2.5 Use particle representations, mathematical models, and macroscopic observations to explain the effect of changes in the macroscopic properties of gases.
2.6 Use data to calculate temperature, pressure, volume, and moles for an ideal gas.
2.7 Use intermolecular forces to explain how solutes separate by chromatography.
2.8 Draw and interpret particle representations of solutions showing interactions between the solute and solvent particles.
2.9 Create and use particle views to interpret molar concentrations of solutions.
2.10 Design an experiment to separate substances using filtration, paper chromatography, column chromatography, or distillation and explain how substances separate citing intermolecular interactions.
2.11 Use London dispersion forces to predict properties and explain trends for nonpolar substances.
2.12 Analyze data for real gases to identify deviations from ideal behavior and explain using molecular interactions.
2.13 Explain how the structural features of polar molecules affect the forces of attraction between them.
2.14 Using particle views, qualitatively apply Coulomb's law to explain how the solubility of ionic compounds is affected by interactions between ions, and attractions between ions and solvents.
2.15 Explain the solubility of ionic solids and molecules in water and other solvents using entropy and particle views to show intermolecular forces.
2.16 Use the strengths and types of intermolecular forces to explain the properties of molecules such as phase, vapor pressure, viscosity, melting point, and boiling point.
2.17 Predict the type of bonding in a binary compound based on electronegativity of the elements and their locations on the periodic table.
2.18 Rank and justify bond polarity using location of atoms on the periodic table.
2.19 Use particle views of ionic compounds to explain the effect of microscopic structure on macroscopic properties such as boiling point, solubility, hardness, brittleness, low volatility, and the lack of malleability, ductility, and conductivity.
2.20 Explain how the electron-sea model of delocalized electrons affects the macroscopic properties of metals such as electrical and thermal conductivity, malleability, ductility, and low volatility.
2.21 Use Lewis diagrams and VSEPR to predict geometry and polarity of molecules and identify hybridization.
2.22 Design and evaluate an experimental plan to collect and interpret data to deduce the types of bonding in solids.
2.23 Create a visual representation of an ionic solid showing its structure and particle interactions.
2.24 Use a visual representation of an ionic solid to explain its structure and particle interactions.
2.25 Compare properties of alloys and metals, identify alloy types, and explain properties at the atomic level.
2.26 Use the electron-sea model to explain the macroscopic properties of metals and alloys.
2.27 Create a visual representation of a metallic solid showing its structure and particle interactions.
2.28 Use a visual representation of a metallic solid to explain its structure and particle interactions.
2.29 Create a visual representation of a covalent solid showing its structure and particle interactions.
2.30 Use a visual representation of a covalent solid to explain its structure and particle interactions.

3.13 Analyze voltaic (galvanic) or electrolytic cell data to identify properties of redox reactions.

Big Idea 5. Thermodynamics describes the role energy plays in physical and chemical changes.

Learning Objectives

5.1 Create and interpret graphical representations that show the dependence of potential energy on the distance between atoms to explain bond order, bond length, bond strength, and the relative magnitudes of intermolecular forces between polar molecules.

5.2 Explain how temperature relates to molecular motion using particle views of moving molecules and plots of Maxwell–Boltzmann distributions.

5.3 Use molecular collisions to explain or predict the transfer of heat between systems.

5.4 Use conservation of energy to explain energy transfer between systems including the quantity of energy transferred, the direction of energy flow, and the type of energy (heat or work).

5.5 Use conservation of energy to calculate and explain the quantity of energy change that occurs when two substances of different temperatures interact.

5.6 Calculate or estimate energy changes associated with a chemical reaction (heat of reaction), a temperature change (heat capacity), or a phase change (heat of fusion or vaporization), and relate energy changes to P_V work.

5.7 Design and interpret a constant pressure calorimetry experiment to determine change in enthalpy of a chemical or physical process.

5.8 Use bond energies to calculate or estimate enthalpies of reaction.

5.9 Explain and predict the relative strengths and types of intermolecular forces acting between molecules using molecular electron density distributions.

5.10 Classify and justify physical and chemical changes using intermolecular forces and changes in chemical bonds.

5.11 Identify the intermolecular forces, such as hydrogen bonds and London dispersions, to explain the shapes and functions of large molecules.

5.12 Use particle views and models to predict the signs and relative magnitudes of the entropy changes associated with chemical or physical processes.

5.13 Use the signs of both _H° and _S° for calculation or estimation of _G°, to predict the thermodynamic favorability of a physical or chemical change.

5.14 Calculate the change in standard Gibbs free energy to determine the thermodynamic favorability of a chemical or physical change.

5.15 Explain how nonthermodynamically favored processes can be made favorable by coupling them with thermodynamically favored reactions.

5.16 Use Le Châtelier's principle to predict direction of reaction for a system in which coupled reactions share a common intermediate.

5.17 Use the equilibrium constant for combined reactions to make predictions for a system involving coupled reactions sharing a common intermediate.

5.18 Explain how initial conditions can greatly affect product formation for both thermodynamically favored and unfavored reactions using thermodynamic and kinetic arguments.

Big Idea 6. Equilibrium represents a balance between enthalpy and entropy for reversible physical and chemical changes.

Learning Objectives

6.1 Given a set of experimental observations, explain on the molecular level, the reversibility of a chemical, biological, or environmental process.

6.2 Predict how manipulating a chemical equation by reversing it, doubling its coefficients, or adding it to another equation affects the value of Q or K.

6.3 Predict the change in relative rates of forward and reverse reactions using Le Châtelier's principle and principles of kinetics.

6.4 Given initial conditions, use the relative values of Q and K to predict the direction a reaction will progress toward equilibrium.

6.5 Calculate the equilibrium constant, K, given the appropriate tabular or graphical data for a system at equilibrium.

6.6 Given initial conditions and the equilibrium constant, K, use stoichiometry and the law of mass action to determine equilibrium concentrations or partial pressures.

2.31 Create a visual representation of a molecular solid showing its structure and particle interactions.

2.32 Use a visual representation of a molecular solid to explain its structure and particle interactions.

Big Idea 4. Molecular collisions determine the rates of chemical reactions.

Learning Objectives

4.1 Design and interpret an experiment to determine the factors that affect reaction rate such as temperature, concentration, and surface area.

4.2 Analyze concentration versus time data to determine the rate law for a zeroth-, first-, and second-order reaction.

4.3 Determine half-life from the rate constant of a first-order reaction and explain the relationship between half-life and reaction order.

4.4 Explain how rate law, order, and rate constant for an elementary reaction relate to the frequency and success of molecular collisions.

4.5 Explain effective and ineffective reactant collisions using energy distributions and molecular orientation.

4.6 Make qualitative predictions about the temperature dependence of reaction rate using an energy profile for an elementary reaction showing reactants, transition state, and products.

4.7 Evaluate alternative reaction mechanisms to determine which are consistent with rate data, and infer the presence of intermediates.

4.8 Use various representations including energy profiles, particle views, and chemical equations to describe chemical reactions that occur with and without catalysts.

4.9 Explain rate changes due to acid–base, surface, and enzyme catalysts, and select appropriate mechanisms with or without catalysts.

6.7 Determine which chemical species will have relatively large and small concentrations given an equilibrium system with a large or small K.

6.8 Use Le Châtelier's principle to predict the direction a reaction at equilibrium will progress when a change is applied such as concentration, pressure, or temperature.

6.9 Design a set of conditions that will optimize a desired result using Le Chatelier's principle.

6.10 Use Le Châtelier's principle to explain the effect a change will have on Q or K for a reversible reaction.

6.11 Construct a particle representation for a strong or weak acid or base to illustrate which species will have large and small concentrations at equilibrium.

6.12 Compare and contrast pH, percentage ionization, concentrations, and the amount of titrant required to reach an equivalence point for solutions of strong and weak acids.

6.13 Interpret titration data to determine concentration of a weak acid or base and its pKa or pKb.

6.14 Explain why a neutral solution requires 3H+4 = 3OH-4 rather than pH = 7, using the dependence of Kw on temperature.

6.15 Calculate or estimate the pH and the concentrations of all species in a mixture of strong acid or base.

6.16 Identify a solution as a weak acid or base, calculate its pH and the concentrations of all species in the solution, and infer its relative strength.

6.17 Given a mixture of weak and strong acids and bases, identify the chemical reaction and tell which species are present in large concentrations at equilibrium.

6.18 Select an appropriate conjugate acid–base pair to design a buffer solution with a target pH and estimate the concentrations needed to achieve a desired buffer capacity.

6.19 Given the pKa, predict the predominant form of a weak acid in a solution of a given pH.

6.20 Identify a buffer solution and explain how it behaves upon addition of acid or base.

6.21 Predict and rank the solubilities of various salts, given their Ksp values.

6.22 Interpret solubility data for various salts to determine or rank Ksp values.

6.23 Use data to predict the influence of pH and common ions on the relative solubilities of salts.

6.24 Use particle representations to explain changes in enthalpy and entropy associated with the dissolution of a salt.

6.25 Use the relationship between _G° and K1_G° = -RT ln K2 to estimate the magnitude of K and the thermodynamic favorability of a process.

Adopted from: Pearson Education: Test Prep Series, AP Chemistry, Edward L. Waterman
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