

“Condensed” Course Content from College Board’s Course Description

This is a general breakdown of what is covered in the Course Description. Please remember - there may be things we teach that are not explicitly written in this list. Sometimes these are really broad or vague, or missing some related concepts that help set you up for success. This can all be found in the College Board’s Course Description in way more detail than here.

1 – Atomic Structure & Properties

~7-9% exam weighting

| Topic & Learning Objective | Essential Knowledge & Exclusion Statements |
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| 1.1 Moles and Molar Mass | 1.1.A.1 One cannot count particles directly while performing laboratory work. Thus, there must be a connection between the masses of substances reacting and the actual number of particles undergoing chemical changes. |
| 1.1.A Calculate quantities of a substance or its relative number of particles using dimensional analysis and the mole concept | 1.1.A.2 Avogadro’s number ($N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$) provides the connection between the number of moles in a pure sample of a substance and the number of constituent particles (or formula units) of that substance. |
| | 1.1.A.3 Expressing the mass of an individual atom or molecule in atomic mass units (amu) is useful because the average mass in amu of one particle (atom or molecule) or formula unit of a substance will always be numerically equal to the molar mass of that substance in grams. Thus, there is a quantitative connection between the mass of a substance and the number of particles that the substance contains. EQN: $n = m/M$ |
| 1.2 Mass Spectroscopy of Elements | 1.2.A.1 The mass spectrum of a sample containing a single element can be used to determine the identity of the isotopes of that element and the relative abundance of each isotope in nature. |
| 1.2.A Explain the quantitative relationship between the mass spectrum of an element and the masses of the element’s isotopes. | 1.2.A.2 The average atomic mass of an element can be estimated from the weighted average of the isotopic masses using the mass of |
| | X - Interpreting mass spectra of samples containing multiple elements or peaks arising from species other than singly charged monatomic ions will not be assessed on the AP Exam. |
| 1.3 Elemental Composition of Pure Substances | 1.3.A.1 Some pure substances are composed of individual molecules, while others consist of atoms or ions held together in fixed proportions as described by a formula unit. |
| 1.3.A Explain the quantitative relationship btwn elemental composition by mass and the empirical formula of a pure substance. | 1.3.A.2 According to the law of definite proportions, the ratio of the masses of the constituent elements in any pure sample of that compound is always the same. |
| | 1.3.A.3 The chemical formula that lists the lowest whole # ratio of atoms of the elements in a compound is the empirical formula. |
| 1.4 Composition of Mixtures | 1.4.A.1 While pure substances contain molecules or formula units of a single type, mixtures contain molecules or formula units of two or more types, whose relative proportions can vary. |
| 1.4.A Explain quantitative relationship btwn the elemental composition by mass and the composition of substances in a mixture. | 1.4.A.2 Elemental analysis can be used to determine the relative numbers of atoms in a substance and to determine its purity. |
| 1.5 Atomic Structure & Electron Configuration | 1.5.A.1 The atom is composed of negatively charged electrons and a positively charged nucleus that is made of protons and neutrons. |
| 1.5.A Represent the electron configuration of an element or ions of an element using the Aufbau principle. | 1.5.A.2 Coulomb’s law is used to calculate the force between two charged particles. EQN: $F_{\text{coulombic}} \propto \frac{q_1q_2}{r^2}$ |
| | 1.5.A.3 In atoms and ions, the electrons can be thought of as being in “shells (energy levels)” and “subshells (sublevels),” as described by the electron configuration. Inner electrons are called core electrons, and outer electrons are called valence electrons. The electron config. is explained by quantum mechanics, as delineated in the Aufbau principle and exemplified in the periodic table of the elements. |
| | X - THE ASSIGNMENT OF QUANTUM NUMBERS TO ELECTRONS IN SUBSHELLS OF AN ATOM WILL NOT BE ASSESSED ON THE AP EXAM. Rationale: Assignment of quantum numbers to electrons in specific subshells does not increase students’ understanding of the structure of the atom. |
| | 1.5.A.4 The relative energy required to remove an e- from different subshells of an atom or ion or from the same subshell in different atoms or ions (ionization energy) can be estimated through a qualitative application of Coulomb’s law. This energy is related to the distance from the nucleus and the effective (shield) charge of the nucleus. |
| 1.6 Photoelectron Spectroscopy | 1.6.A.1 The energies of the electrons in a given shell can be measured experimentally with photoelectron spectroscopy (PES). The position of each peak in the PES spectrum is related to the energy required to remove an electron from the corresponding subshell, and the height of each peak is (ideally) proportional to the number of electrons in that subshell. |
| 1.6.A Explain the relationship between the photoelectron spectrum of an atom or ion and: a. The e- config. b. The interactions btwn e-’s & nucleus | |

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| 1.7 Periodic Trends | 1.7.A.1 The organization of the periodic table is based on the recurring properties of the elements and explained by the pattern of electron configurations and the presence of completely or partially filled shells (and subshells) of electrons in atoms |
| 1.7.A The periodic table shows patterns in electronic structure and trends in the atomic properties | X - WRITING THE ELECTRON CONFIG. OF ELEMENTS THAT ARE EXCEPTIONS TO THE AUFBAU PRINCIPLE WILL NOT BE ASSESSED ON THE AP EXAM. Rationale: The mere rote recall of the exceptions does not match the goals of the curriculum revision. 1.7.A.2 Trends in atomic properties within the periodic table (periodicity) can be qualitatively understood through the position of the element in the periodic table, Coulomb's law, the shell model, and the concept of shielding/effective nuclear charge. These properties include: a. Ionization energy b. Atomic and ionic radii c. Electron affinity d. Electronegativity. 1.7.A.3 The periodicity is useful to predict/estimate values of properties in absence of data. |
| 1.8 Valence e⁻s and Ionic Compounds | 1.8.A.1 The likelihood that two elements will form a chemical bond is determined by the interactions between the valence electrons and nuclei of elements. |
| 1.8.A Explain the relationship between trends in the reactivity of elements and periodicity. | 1.8.A.2 Elements in the same column of the periodic table tend to form analogous compounds. 1.8.A.3 Typical charges of atoms in ionic compounds are governed by their location on the periodic table and the number of valence electrons. |

2 – Molecular and Ionic Compound Structure and Properties

~7-9% exam weighting

| Topic & Enduring Understanding | Learning Objective | Essential Knowledge & Exclusion Statements |
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| 2.1 Types of Chemical Bonds | 2.1.A.1 Electronegativity values for the representative elements increase going from left to right across a period and decrease going down a group. These trends can be understood qualitatively through the electronic structure of atoms, the shell model, and Coulomb's law. | |
| 2.1.A Explain the relationship between the type of bonding and the properties of the elements participating in the bond. | 2.1.A.2 Valence electrons shared btwn atoms of similar electronegativity constitute a nonpolar covalent bond. For example, bonds between C and H are effectively nonpolar even though carbon is slightly more electronegative than hydrogen. 2.1.A.3 Valence electrons shared between atoms of unequal electronegativity constitute a polar covalent bond. a. The atom with a higher electronegativity will develop a partial negative charge relative to the other atom in the bond. b. In single bonds, greater differences in electronegativity lead to greater bond dipoles. c. All polar bonds have some ionic character, and the difference between ionic and covalent bonding is not distinct but rather a continuum. 2.1.A.4 The difference in electronegativity is not the only factor in determining if a bond should be designated as ionic or covalent. Generally, bonds between a metal and nonmetal are ionic, and bonds between two nonmetals are covalent. Examination of the properties of a compound is the best way to characterize the type of bonding. 2.1.A.5 In a metallic solid, the valence e ⁻ s from the metal atoms are delocalized and not associated with any individual atom. | |
| 2.2 Intramolecular Force and Potential Energy | 2.2.A.1 A graph of potential energy versus the distance between atoms is a useful representation for describing the interactions between atoms. Such graphs illustrate both the equilibrium bond length (the separation between atoms at which the potential energy is lowest) and the bond energy (the energy required to separate the atoms). 2.2.A.2 In a covalent bond, the bond length is influenced by both the size of the atom's core and the bond order (i.e., single, double, triple). Bonds with a higher order are shorter and have larger bond energies. 2.2.A.3 Coulomb's law can be used to understand the strength of interactions between cations and anions. a. Because the interaction strength is proportional to the charge on each ion, larger charges lead to stronger interactions. b. Because the interaction strength increases as the distance btwn the centers of the ions (nuclei) decr., smaller ions lead to stronger interactions. | |
| 2.2.A Represent the relationship between potential energy and distance between atoms, based on factors that influence the interaction strength. | | |
| 2.3 Structure of Ionic Solids | 2.3.A.1 The cations and anions in an ionic crystal are arranged in a systematic, periodic 3-D array that maximizes the attractive forces among cations and anions while minimizing the repulsive forces. | |
| 2.3.A Represent an ionic solid with a particulate model that is consistent with Coulomb's law and the properties of the constituent ions. | X - KNOWLEDGE OF SPECIFIC TYPES OF CRYSTAL STRUCTURES WILL NOT BE ASSESSED ON THE AP EXAM. Rationale: Study of specific crystal structures is not essential to an understanding of the big ideas. | |
| 2.4 Structure of Metals and Alloys | 2.4.A.1 Metallic bonding can be represented as an array of positive metal ions surrounded by delocalized valence electrons (i.e., a "sea of electrons"). 2.4.A.2 Interstitial alloys form between atoms of different radii, where the smaller atoms fill the interstitial spaces between the larger atoms (e.g., with steel in which carbon occupies the interstices in iron). 2.4.A.3 Substitutional alloys form between atoms of comparable radius, where one atom substitutes for the other in the lattice. In certain brass alloys, other elements, usually Zn, subst. for Cu. | |
| 2.4.A Represent a metallic solid and/or alloy using a model to show essential characteristics of the structure and interactions present in the substance. | | |

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| 2.5 Lewis Diagrams | 2.5.A.1 Lewis diagrams can be constructed according to an established set of principles. |
| 2.5.A Represent a molecule with a Lewis diagram. | |
| 2.6 Resonance and Formal Charge | 2.3.A.1 In cases where more than one equivalent Lewis structure can be constructed, resonance must be included as a refinement to the Lewis structure. In many such cases, this refinement is needed to provide qualitatively accurate predictions of molecular structure and properties. |
| 2.6.A Represent a molecule w/ a Lewis diagram that accounts for resonance btwn equivalent structures or that uses formal charge to select btwn nonequivalent structures. | 2.6.A.2 Octet rule & formal charge can be used as criteria for determining which possible valid Lewis diagrams provides the best model for predicting molecular structure and properties. |
| | 2.6.A.3 As with any model, there are limitations to the use of the Lewis structure model, particularly in cases with an odd number of valence electrons. |
| 2.7 VSEPR and Bond Hybridization | 2.7.A.1 VSEPR theory uses the Coulombic repulsion between electrons as a basis for predicting the arrangement of electron pairs around a central atom. |
| 2.7.A Based on the relationship between Lewis diagrams, VSEPR theory, bond orders, and bond polarities: a. Explain structural properties of molecules. b. Explain electron properties of molecules. | 2.7.A.2 Both Lewis diagrams and VSEPR theory must be used for predicting electronic and structural properties of many covalently bonded molecules and polyatomic ions, including the following: a. Molecular geometry b. Bond angles c. Relative bond energies based on bond order d. Relative bond lengths (multiple bonds, effects of atomic radius) e. Presence of a dipole moment f. Hybridization of valence orbitals of the molecule |
| | 2.7.A.3 The terms “hybridization” and “hybrid atomic orbital” are used to describe the arrangement of electrons around a central atom. When the central atom is sp hybridized, its ideal bond angles are 180°; for sp ² hybridized atoms the bond angles are 120°; and for sp ³ hybridized atoms the bond angles are 109.5°. |
| | X - AN UNDERSTANDING OF THE DERIVATION AND DEPICTION OF HYBRID ORBITALS WILL NOT BE ASSESSED ON THE AP EXAM. Rationale: The course includes the distinction between sigma and pi bonding, the use of VSEPR to explain the shapes of molecules, and the sp, sp², and sp³ nomenclature. Additional aspects related to hybridization are both controversial and do not substantially enhance understanding of molecular structure. |
| | X - HYBRIDIZATION INVOLVING D ORBITALS WILL NOT BE ASSESSED ON THE AP EXAM. WHEN AN ATOM HAS MORE THAN FOUR PAIRS OF ELECTRONS SURROUNDING THE CENTRAL ATOM, STUDENTS ARE ONLY RESPONSIBLE FOR THE SHAPE OF THE RESULTING MOLECULE. Rationale: Current evidence suggests that main-group hybridization involving d orbitals does not exist, and there is controversy about the need to teach any hybridization. Until agreement is reached in the chemistry community, we will continue to include only sp, sp², and sp³ hybridization on the AP Exam. |
| | 2.7.A.4 Bond formation is associated with overlap btwn atomic orbitals. In multiple bonds, overlap leads to the formation of both sigma and pi bonds. Overlap is stronger in sigma than pi bonds, which is reflected in sigma bonds having greater bond energy than pi bonds. The presence of a pi bond also prevents the rotation of the bond and leads to structural isomers. |
| | X - MOLECULAR ORBITAL THEORY IS RECOMMENDED AS A WAY TO PROVIDE DEEPER INSIGHT INTO BONDING. HOWEVER, THE AP EXAM WILL NEITHER EXPLICITLY ASSESS MO DIAGRAMS, FILLING OF MOLECULAR ORBITALS, NOR THE DISTINCTION BETWEEN BONDING, NONBONDING, AND ANTBONDING ORBITALS. Rationale: As currently covered in general chemistry college textbooks, molecular orbital theory is limited to homonuclear molecules in the second period. |

3 – Properties of Substances and Mixtures

~18-22% exam weighting

| Topic & Enduring Understanding | Learning Objective | Essential Knowledge & Exclusion Statements |
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| 3.1 Intermolecular and Interparticle Forces | 3.1.A.A London dispersion forces are a result of the Coulombic interactions between temporary, fluctuating dipoles. London dispersion forces are often the strongest net intermolecular force between large molecules. a. Dispersion forces increase with increasing contact area between molecules and with increasing polarizability of the molecules. b. The polarizability of a molecule increases with an increasing number of electrons in the molecule; and the size of the electron cloud. It is enhanced by the presence of pi bonding. c. The term “London dispersion forces” should not be used synonymously with the term “van der Waals forces.” | |
| 3.1.a Explain relationship btwn chemical structures of molecules & relative strength of the IMFs when a. The molecules are the same chemical species. b. The molecules are of two different chemical species. | 3.1.A.2 The dipole moment of a polar molecule leads to additional interactions with other chemical species. a. Dipole-induced dipole interactions are present btwn a polar & nonpolar molecule. These forces are always attractive. The strength of these forces incr. w/ the magnitude of the dipole of the polar molecule and with the polarizability of the nonpolar molecule. b. Dipole-dipole interactions are present btwn polar molecules. The interaction strength depends on the magnitudes of the dipoles & their relative orientation. Interactions btwn polar molecules are typically greater than those btwn nonpolar molecules of comparable size because these interactions act in addition to LDF forces. c. Ion-dipole forces of attraction are present btwn ions and polar molecules. These tend to be stronger than dipole-dipole forces. | |
| | 3.1.A.3 Relative strength & orientation dependence of DP-DP & ion-dipole forces can be understood qualitatively by considering the sign of the partial charges responsible for the molecular dipole moment, & how these partial charges interact w/ an ion or w/ an adjacent dipole. | |
| | 3.1.A.4 Hydrogen bonding is a strong type of intermolecular interaction that exists when hydrogen atoms covalently bonded to the highly electronegative atoms (N, O, and F) are attracted to the negative end of a dipole formed by the electronegative atom (N, O, and F) in a different molecule, or a different part of the same molecule. | |
| | 3.1.A.5 In large biomolecules, noncovalent interactions may occur between different molecules or between different regions of the same large biomolecule. | |

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| 3.2 Properties of Solids | 3.2.A.1 Many properties of liquids and solids are determined by the strengths and types of intermolecular forces present. Because intermolecular interactions are broken when a substance vaporizes, the vapor pressure and boiling point are directly related to the strength of those interactions. Melting points also tend to correlate with interaction strength, but because the interactions are only rearranged, in melting, the relations can be more subtle. |
| 3.2.A Explain the relationship among the macroscopic properties of a substance, the particulate-level structure of the substance, and the interactions between these particles. | 3.2.A.2 Particulate-level representations, showing multiple interacting chemical species, are a useful means to communicate or understand how intermolecular interactions help to establish macroscopic properties. |
| | 3.2.A.3 Due to strong interactions btwn ions, ionic solids tend to have low vapor pressures, high melting/boiling points. They tend to be brittle due to the repulsion of like charges caused when one layer slides across another layer. They conduct electricity only when the ions are mobile, as when the ionic solid is melted or dissolved in water or another solvent. |
| | 3.2.A.4 In covalent network solids, the atoms are covalently bonded together into a three dimensional network (e.g., diamond) or layers of two-dimensional networks (e.g., graphite). These are only formed from nonmetals: elemental (e.g., diamond, graphite) or binary compounds of two nonmetals (e.g., silicon dioxide and silicon carbide). Due to the strong covalent interactions, covalent solids have high melting points. Three-dimensional network solids are also rigid and hard, because the covalent bond angles are fixed. However, graphite is soft because adjacent layers can slide past each other relatively easily. |
| | 3.2.A.5 Molecular solids are composed of distinct, individual units of covalently-bonded molecules attracted to each other through relatively weak intermolecular forces. Molecular solids generally have a low melting point because of the relatively weak intermolecular forces present between the molecules. They do not conduct electricity because their valence electrons are tightly held within the covalent bonds and the lone pairs of each constituent molecule. Molecular solids are sometimes composed of very large molecules or polymers. |
| | 3.2.A.6 Metallic solids are good conductors of electricity and heat, due to the presence of free valence electrons. They also tend to be malleable and ductile, due to the ease with which the metal cores can rearrange their structure. In an interstitial alloy, interstitial atoms tend to make the lattice more rigid, decreasing malleability and ductility. Alloys typically retain a sea of mobile electrons and so remain conducting. |
| | 3.2.A.7 In large biomolecules or polymers, noncovalent interactions may occur between different molecules or between different regions of the same large biomolecule. The functionality and properties of such molecules depend strongly on the shape of the molecule, which is largely dictated by noncovalent interactions. |
| 3.3 Solids, Liquids, and Gases | 3.3.A.1 Solids can be crystalline, where the particles are arranged in a regular three-dimensional structure, or they can be amorphous, where the particles do not have a regular, orderly arrangement. In both cases, the motion of the individual particles is limited, and the particles do not undergo overall translation with respect to each other. The structure of the solid is influenced by interparticle interactions and the ability of the particles to pack together. |
| 3.3.A Represent the differences between solid, liquid, and gas phases using a particulate level model. | 3.3.A.2 The constituent particles in liquids are in close contact with each other, and they are continually moving and colliding. The arrangement and movement of particles are influenced by the nature and strength of the forces (e.g., polarity, hydrogen bonding, and temperature) between the particles. |
| | 3.3.A.3 The solid and liquid phases for a particular substance typically have similar molar volume because, in both phases, the constituent particles are in close contact at all times. |
| | 3.3.A.4 In the gas phase, the particles are in constant motion. Their frequencies of collision and the average spacing between them are dependent on temperature, pressure, and volume. Because of this constant motion, and minimal effects of forces between particles, a gas has neither a definite volume nor a definite shape. |
| | <i>X - UNDERSTANDING/INTERPRETING PHASE DIAGRAMS WILL NOT BE ASSESSED ON THE AP EXAM. Rationale: Phase diagrams of pure substances are considered prior knowledge.</i> |
| 3.4 Ideal Gas Law | 3.4.A.1 The macroscopic properties of ideal gases are related through the ideal gas law: EQN: $PV = nRT$. |
| 3.4.A Explain the relationship between the macroscopic properties of a sample of gas or mixture of gases using the ideal gas law. | 3.4.A.2 In a sample containing a mixture of ideal gases, the pressure exerted by each component (the partial pressure) is independent of the other components. Therefore, the total pressure of the sample is the sum of the partial pressures. EQN: $P_A = P_{total} \times X_A$, where X_A = moles A/total moles; EQN: $P_{total} = P_A + P_B + P_C + \dots$ |
| | 3.4.A.3 Graphical representations of the relationships between P, V, T, and n are useful to describe gas behavior. |
| 3.5 Kinetic Molecular Theory | 3.5.A.1 The kinetic molecular theory (KMT) relates the macroscopic properties of gases to motions of the particles in the gas. The Maxwell-Boltzmann distribution describes the distribution of the kinetic energies of particles at a given temperature. |
| 3.5.A Explain the relationship between the motion of particles and the macroscopic properties of gases with: a. The kinetic molecular theory (KMT). b. A particulate model. c. A graphical representation. | 3.5.A.2 All the particles in a sample of matter are in continuous, random motion. The average kinetic energy of a particle is related to its average velocity by the equation: EQN: $KE = \frac{1}{2} mv^2$. |
| | 3.5.A.3 The Kelvin temperature of a sample of matter is proportional to the average kinetic energy of the particles in the sample. |
| | 3.5.A.4 The Maxwell-Boltzmann distribution provides a graphical representation of the energies/ velocities of particles at a given temperature. |

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| 3.6 Deviation from Ideal Gas Law | 3.6.A.1 The ideal gas law does not explain the actual behavior of real gases. Deviations from the ideal gas law may result from interparticle attractions among gas molecules, particularly at conditions that are close to those resulting in condensation. Deviations may also arise from particle volumes, particularly at extremely high pressures. | |
| 3.6.A Explain the relationship among non-ideal behaviors of gases, interparticle forces, and/or volumes. | | |
| 3.7 Solutions and Mixtures | 3.7.A.1 Solutions, also sometimes called homogeneous mixtures, can be solids, liquids, or gases. In a solution, the macroscopic properties do not vary throughout the sample. In a heterogeneous mixture, the macroscopic properties depend on location in the mixture. | |
| 3.7.A Calculate the number of solute particles, volume, or molarity of solutions. | 3.7.A.2 Solution composition can be expressed in a variety of ways; molarity is the most common method used in the laboratory. EQN: $M = n_{\text{solute}} / L_{\text{solution}}$ | |
| 3.8 Representations of Solutions | 3.8.A.1 Particulate representations of solutions communicate the structure and properties of solutions, by illustration of the relative concentrations of the components in the solution and drawings that show interactions among the components. | |
| 3.8.A Using particulate models for mixtures: a. Represent interactions between components. b. Represent concentrations of components. | X - COLLIGATIVE PROPERTIES WILL NOT BE ASSESSED ON THE AP EXAM. | |
| | X - CALCULATIONS OF MOLALITY, PERCENT BY MASS, AND PERCENT BY VOLUME WILL NOT BE ASSESSED ON THE AP EXAM. | |
| 3.9 Separation of Solutions & Mixtures | 3.9.A.1 The components of a liquid solution cannot be separated by filtration. They can, however, be separated using processes that take advantage of differences in the intermolecular interactions of the components. | |
| 3.9.A Explain the results of a separation experiment based on IMF interactions. | a. Chromatography (paper, thin-layer, and column) separates chemical species by taking advantage of the differential strength of intermolecular interactions between and among the components of the solution (the mobile phase) and with the surface components of the stationary phase. b. Distillation separates chemical species by taking advantage of the differential strength of intermolecular interactions between and among the components and the effects these interactions have on the vapor pressures of the components in the mixture. | |
| 3.10 Solubility | 3.10.A.1 Substances with similar intermolecular interactions tend to be miscible or soluble in one another | |
| 3.10.A Explain the relationship between the solubility of ionic and molecular compounds in aqueous and nonaqueous solvents, and the intermolecular interactions between particles. | | |
| 3.11 Spectroscopy and the Electromagnetic Spectrum | 3.11.A.1 Differences in absorption or emission of photons in different spectral regions are related to the different types of molecular motion or electronic transition: | |
| 3.11.a Explain the relationship between a region of the electromagnetic spectrum and the types of molecular or electronic transitions associated with that region. | a. Microwave radiation is associated with transitions in molecular rotational levels. b. Infrared radiation is associated with transitions in molecular vibrational levels. c. Ultraviolet/visible radiation is associated with transitions in electronic energy levels. | |
| 3.12 Properties of Photons | 3.12.A.1 When a photon is absorbed (or emitted) by an atom or molecule, the energy of the species is increased (or decreased) by an amount equal to the energy of the photon. | |
| 3.12.a Explain the properties of an absorbed or emitted photon in relationship to an electronic transition in an atom or molecule. | 3.12.A.2 The wavelength of the electromagnetic wave is related to its frequency and the speed of light by the equation: EQN: $c = \lambda\nu$. The energy of a photon is related to the frequency of the electromagnetic wave through Planck's equation ($E = h\nu$). | |
| 3.13 Beer-Lambert Law | 3.13.A.1 The Beer-Lambert law relates the absorption of light by a solution to three variables according to the equation: EQN: $A = \epsilon bc$. | |
| 3.13.A Explain the amount of light absorbed by a solution of molecules or ions in relationship to the concentration, path length, and molar absorptivity. | The molar absorptivity ϵ describes how intensely a sample of molecules or ions absorbs light of a specific wavelength. The path length b and concentration c are proportional to the number of absorbing species. | |
| | 3.13.A.2 In most experiments the path length and wavelength of light are held constant. In such cases, the absorbance is proportional only to the concentration of absorbing molecules or ions. | |

4 – Chemical Reactions

~7 -9% exam weighting

| Topic & Enduring Understanding | Learning Objective | Essential Knowledge & Exclusion Statements |
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| 4.1 Introduction for Reactions | TRA - 1.A.1 | A physical change occurs when a substance undergoes a change in properties but not a change in composition. Changes in the phase of a substance (solid, liquid, gas) or formation/ separation of mixtures of substances are common physical changes. |
| TRA – 1.A Identify evidence of chemical and physical changes in matter. | TRA - 1.A.2 | A chemical change occurs when substances are transformed into new substances, typically with different compositions. Production of heat or light, formation of a gas, formation of a precipitate, and/or color change provide possible evidence that a chemical change has occurred. |
| 4.2 Net Ionic Equations | TRA - 1.B.1 | All physical and chemical processes can be represented symbolically by balanced equations. |
| TRA – 1.B Represent changes in matter with a balanced chemical or net ionic equation: a. For physical changes. b. For given information about the identity of the reactants and/or product. c. For ions in a given chemical reaction. | TRA - 1.B.2 | Chemical equations represent chemical changes. These changes are the result of a rearrangement of atoms into new combinations; thus, any representation of a chemical change must contain equal numbers of atoms of every element before and after the change occurred. Equations thus demonstrate that mass is conserved in chemical reactions. |
| | TRA - 1.B.3 | Balanced molecular, complete ionic, and net ionic equations are differing symbolic forms used to represent a chemical reaction. The form used to represent the reaction depends on the context in which it is to be used. |
| 4.3 Representations of Reactions | TRA - 1.C.1 | Balanced chemical equations in their various forms can be translated into symbolic particulate representations. |
| TRA – 1.C Represent a given chemical reaction or physical process with a consistent particulate model. | | |
| 4.4 Physical and Chemical Changes | TRA - 1.D.1 | Processes that involve the breaking and/or formation of chemical bonds are typically classified as chemical processes. Processes that involve only changes in intermolecular interactions, such as phase changes, are typically classified as physical processes. |
| TRA – 1.D Explain the relationship between macroscopic characteristics and bond interactions for: a. Chemical processes. b. Physical processes. | TRA - 1.D.2 | Sometimes physical processes involve the breaking of chemical bonds. For example, plausible arguments could be made for the dissolution of a salt in water, as either a physical or chemical process, involves breaking of ionic bonds, and the formation of ion-dipole interactions between ions and solvent. |
| 4.5 Stoichiometry | SPQ - 4.A.1 | Because atoms must be conserved during a chemical process, it is possible to calculate product amounts by using known reactant amounts, or to calculate reactant amounts given known product amounts. |
| SPQ – 4.A Explain changes in the amounts of reactants and products based on the balanced reaction equation for a chemical process. | SPQ - 4.A.2 | Coefficients of balanced chemical equations contain information regarding the proportionality of the amounts of substances involved in the reaction. These values can be used in chemical calculations involving the mole concept. |
| | SPQ - 4.A.3 | Stoichiometric calculations can be combined with the ideal gas law and calculations involving molarity to quantitatively study gases and solutions. |
| 4.6 Introduction to Titration | SPQ - 4.B.1 | Titration may be used to determine the concentration of an analyte in solution. The titrant has a known concentration of a species that reacts specifically and quantitatively with the analyte. The equivalence point of the titration occurs when the analyte is totally consumed by the reacting species in the titrant. The equivalence point is often indicated by a change in a property (such as color) that occurs when the equivalence point is reached. This observable event is called the endpoint of the titration. |
| SPQ – 4.B Identify the equivalence point in a titration based on the amounts of the titrant and analyte, assuming the titration | | |

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| reaction goes to completion. | | |
| 4.7 Types of Chemical Reactions | TRA - 2.A.1 All physical and chemical processes can be represented symbolically by balanced equations. | |
| TRA – 2.A Identify a reaction as acid base, oxidation-reduction, or precipitation. | TRA - 2.A.2 Oxidation-reduction reactions involve transfer of one or more electrons between chemical species, as indicated by changes in oxidation numbers of the involved species. Combustion is an important subclass of oxidation-reduction reactions, in which a species reacts with oxygen gas. In the case of hydrocarbons, carbon dioxide and water are products of complete combustion. | |
| | TRA - 2.A.3 In a redox reaction, electrons are transferred from the species that is oxidized to the species that is reduced. X - THE MEANING OF THE TERMS "REDUCING AGENT" AND "OXIDIZING AGENT" WILL NOT BE ASSESSED ON THE AP EXAM. Rationale: Understanding this terminology is not necessary for reasoning about redox chemistry. | |
| | TRA - 2.A.4 Oxidation numbers may be assigned to each of the atoms in the reactants and products; this is often an effective way to identify the oxidized and reduced species in a redox reaction. | |
| | TRA - 2.A.5 Precipitation reactions frequently involve mixing ions in aqueous solution to produce an insoluble or sparingly soluble ionic compound. All sodium, potassium, ammonium, and nitrate salts are soluble in water. X - ROTE MEMORIZATION OF "SOLUBILITY RULES" OTHER THAN THOSE IMPLIED IN TRA-2.A.5 WILL NOT BE ASSESSED ON THE AP EXAM. | |
| 4.8 Introduction to Acid-Base Reactions | TRA - 2.B.1 By definition, a Brønsted-Lowry acid is a proton donor and a Brønsted-Lowry base is a proton acceptor.. | |
| TRA – 2.B Identify species as Brønsted Lowry acids, bases, and/or conjugate acid-base pairs, based on proton-transfer involving those species. | TRA - 2.B.2 Only in aqueous solutions, water plays an important role in many acid-base reactions, as its molecular structure allows it to accept protons from and donate protons to dissolved species. | |
| | TRA - 2.B.3 When an acid or base ionizes in water, the conjugate acid-base pairs can be identified and their relative strengths compared. X - LEWIS ACID-BASE CONCEPTS WILL NOT BE ASSESSED ON THE AP EXAM. Rationale: Lewis acid-base concepts are important ideas for organic chemistry. However, as the emphasis in AP Chemistry is on reactions in aqueous solution, these concepts will not be examined. | |
| 4.9 Oxidation-Reduction (Redox) Reactions | TRA - 2.C.1 Balanced chemical equations for redox reactions can be constructed from half-reactions. | |
| TRA – 2.C Represent a balanced redox reaction equation using half-reactions. | | |
| 5 – Kinetics ~7 -9% exam weighting | | |
| Topic & Enduring Understanding | Learning Objective | Essential Knowledge & Exclusion Statements |
| 5.1 Reactions Rate | TRA - 3.A.1 The kinetics of a chemical reaction is defined as the rate at which an amount of reactants is converted to products per unit of time. | |
| TRA – 3.A Explain the relationship between the rate of a chemical reaction and experimental parameters. | TRA – 3.A.2 The rates of change of reactant and product concentrations are determined by the stoichiometry in the balanced chemical equation. | |
| | TRA – 3.A.3 The rate of a reaction is influenced by reactant concentrations, temperature, surface area, catalysts, and other environmental factors. | |
| 5.2 Intro to Rate Law | TRA - 3.B.1 Experimental methods can be used to monitor the amounts of reactants and/or products of a reaction and to determine the rate of the reaction. | |
| TRA – 3.B Represent experimental data with a consistent rate law expression. | TRA – 3.B.2 The rate law expresses the rate of a reaction as proportional to the concentration of each reactant raised to a power. | |
| | TRA – 3.B.3 The power of each reactant in the rate law is the order of the reaction with respect to that reactant. The sum of the powers of the reactant concentrations in the rate law is the overall order of the reaction. | |
| | TRA – 3.B.4 The proportionality constant in the rate law is called the rate constant. The value of this constant is temperature dependent and the units reflect the overall reaction order. | |

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| | TRA – 3.B.5 Comparing initial rates of a reaction is a method to determine the order with respect to each reactant. |
| 5.3 Concentration Changes Over Time | TRA - 3.C.1 Experimental methods can be used to monitor the amounts of reactants and/or products of a reaction and to determine the rate of the reaction. |
| TRA – 3.C Identify the rate law expression of a chemical reaction using data that show how the concentrations of reaction species change over time. | TRA – 3.C.2 If a reaction is first order with respect to a reactant being monitored, a plot of the natural log (ln) of the reactant concentration as a function of time will be linear. |
| | TRA – 3.C.3 If a reaction is second order with respect to a reactant being monitored, a plot of the reciprocal of the concentration of that reactant versus time will be linear. |
| | TRA – 3.C.4 The slopes of the concentration versus time data for zeroth, first, and second order reactions can be used to determine the rate constant for the reaction. Zeroth order: EQN: $[A]_t - [A]_0 = -kt$ First order: EQN: $\ln[A]_t - \ln[A]_0 = -kt$ Second order: EQN: $1/[A]_t - 1/[A]_0 = kt$ |
| | TRA – 3.C.5 Half-life is a critical parameter for first order reactions because the half-life is constant and related to the rate constant for the reaction by the equation: EQN: $t_{1/2} = 0.693/k$. |
| | TRA – 3.C.6 Radioactive decay processes provide an important illustration of first order kinetics. |
| | 5.4 Elementary Reactions |
| TRA – 4.A Represent an elementary reaction as a rate law expression using stoichiometry. | TRA - 4.A.2 Elementary reactions involving the simultaneous collision of three or more particles are rare. |
| 5.5 Collision Model | TRA - 4.B.1 The rate law of an elementary reaction can be inferred from the stoichiometry of the molecules participating in a collision. |
| TRA – 4.B Explain the relationship between the rate of an elementary reaction and the frequency, energy, and orientation of molecular collisions. | TRA - 4.B.2 In most reactions, only a small fraction of the collisions leads to a reaction. Successful collisions have both sufficient energy to overcome energy barriers and orientations that allow the bonds to rearrange in the required manner. |
| | TRA - 4.B.3 The Maxwell-Boltzmann distribution curve describes the distribution of particle energies; this distribution can be used to gain a qualitative estimate of the fraction of collisions with sufficient energy to lead to a reaction, and also how that fraction depends on temperature. |
| 5.6 Reaction Energy Profile | TRA - 4.C.1 Elementary reactions typically involve the breaking of some bonds and the forming of new ones. |
| TRA – 4.C Represent the activation energy and overall energy change in an elementary reaction using a reaction energy profile. | TRA - 4.C.2 The reaction coordinate is the axis along which the complex set of motions involved in rearranging reactants to form products can be plotted. |
| | TRA - 4.C.3 The energy profile gives the energy along the reaction coordinate, which typically proceeds from reactants, through a transition state, to products. The energy difference between the reactants and the transition state is the activation energy for the forward reaction. |
| | TRA - 4.C.4 The Arrhenius equation relates the temperature dependence of the rate of an elementary reaction to the activation energy needed by molecular collisions to reach the transition state. |
| | X - CALCULATIONS INVOLVING ARRHENIUS EQUATION WILL NOT BE ASSESSED ON AP EXAM. |
| 5.7 Introduction to Reaction Mechanisms | TRA – 5.A.1 A reaction mechanism consists of a series of elementary reactions, or steps, that occur in sequence. The components may include reactants, intermediates, products, and catalysts. |
| TRA – 5.A Identify the components of a reaction mechanism. | TRA – 5.A.2 The elementary steps when combined should align with the overall balanced equation of a chemical reaction. |
| | TRA – 5.A.3 A reaction intermediate is produced by some elementary steps and consumed by others, such that it is present only while a reaction is occurring. |
| | TRA – 5.A.4 Experimental detection of a reaction intermediate is a common way to build evidence in support of one reaction mechanism over an alternative mechanism. |
| | X - COLLECTION OF DATA PERTAINING TO DETECTION OF A REACTION INTERMEDIATE WILL NOT BE ASSESSED ON THE AP EXAM. Rationale: Designing an experiment to identify reaction intermediates often requires knowledge that is beyond the scope of a general chemistry course. |
| 5.8 Reaction Mechanism and Rate Law | TRA – 5.B.1 For reaction mechanisms in which each elementary step is irreversible, or in which the first step is rate limiting, the rate law of the reaction is set by the molecularity of the slowest elementary step (i.e., the rate-limiting step). |

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| TRA – 5.B Identify the rate law for a reaction from a mechanism in which the first step is rate limiting. | X - COLLECTION OF DATA PERTAINING TO DETECTION OF A REACTION INTERMEDIATE WILL NOT BE ASSESSED ON THE AP EXAM. Rationale: Designing an experiment to identify reaction intermediates often requires knowledge that is beyond the scope of a general chemistry course. | |
| 5.9 Steady-State Approximation TRA – 5.C Identify the rate law for a reaction from a mechanism in which the first step is not rate limiting. | TRA – 5.C.1 If the first elementary reaction is not rate limiting, approximations (such as steady state) must be made to determine a rate law expression. | |
| 5.10 Multistep Reaction Energy Profile TRA – 5.D Represent the activation energy and overall energy change in a multistep reaction with a reaction energy profile. | TRA – 5.D.1 Knowledge of the energetics of each elementary reaction in a mechanism allows for the construction of an energy profile for a multistep reaction. | |
| 5.11 Catalysis ENE – 1.A Explain the relationship between the effect of a catalyst on a reaction and changes in the reaction mechanism. | ENE – 1.A.1 In order for a catalyst to increase the rate of a reaction, the addition of the catalyst must increase the number of effective collisions and/ or provide a reaction path with a lower activation energy relative to the original reaction coordinate. ENE – 1.A.2 In a reaction mechanism containing a catalyst, the net concentration of the catalyst is constant. However, the catalyst will frequently be consumed in the rate-determining step of the reaction, only to be regenerated in a subsequent step in the mechanism. ENE – 1.A.3 Some catalysts accelerate a rxn by binding to the reactant(s). The reactants are either oriented more favorably or react with lower activation energy. There is often a new rxn intermediate in which the catalyst is bound to reactant(s). Many enzymes function this way. ENE – 1.A.4 Some catalysts involve covalent bonding between the catalyst and the reactant(s). An example is acid-base catalysis, in which a reactant or intermediate either gains or loses a proton. This introduces a new reaction intermediate and new elementary reactions involving that intermediate. ENE – 1.A.5 In surface catalysis, a reactant or intermediate binds to, or forms a covalent bond with, the surface. This introduces elementary rxns involving these new bound reaction intermediate(s). | |
| 6 – Thermodynamics ~7-9% exam weighting | | |
| Topic & Enduring Understanding | Learning Objective | Essential Knowledge & Exclusion Statements |
| 6.1 Endothermic and Exothermic Processes ENE – 2.A Explain the relationship between experimental observations and energy changes associated with a chemical or physical transformation. | ENE - 2.A.1 Temperature changes in a system indicate energy changes. ENE – 2.A.2 Energy changes in a system can be described as endothermic and exothermic processes such as the heating or cooling of a substance, phase changes, or chemical transformations. ENE – 2.A.3 When a chemical reaction occurs, the energy of the system either decreases (exothermic reaction), increases (endothermic reaction), or remains the same. For exothermic reactions, the energy lost by the reacting species (system) is gained by the surroundings, as heat transfer from or work done by the system. Likewise, for endothermic reactions, the system gains energy from the surroundings by heat transfer to or work done on the system. ENE – 2.A.4 The formation of a solution may be an exothermic or endothermic process, depending on the relative strengths of intermolecular/interparticle interactions before and after the dissolution process. | |
| 6.2 Energy Diagrams ENE – 2.B Represent a chemical or physical transformation with an energy diagram. | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. | |

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| 6.3 Heat Transfer and Thermal Equilibrium | ENE – 2.C.1 The particles in a warmer body have a greater average kinetic energy than those in a cooler body. |
| ENE – 2.C Explain the relationship between the transfer of thermal energy and molecular collisions. | ENE – 2.C.2 Collisions between particles in thermal contact can result in the transfer of energy. This process is called “heat transfer,” “heat exchange,” or “transfer of energy as heat.” |
| | ENE – 2.C.3 Eventually, thermal equilibrium is reached as the particles continue to collide. At thermal equilibrium, the average kinetic energy of both bodies is the same, and hence, their temperatures are the same. |
| 6.4 Heat Capacity and Calorimetry | ENE - 2.D.1 The heating of a cool body by a warmer body is an important form of energy transfer between two systems. The amount of heat transferred between two bodies may be quantified by the heat transfer equation: EQN: $q = mc\Delta T$. Calorimetry experiments are used to measure the transfer of heat. |
| ENE – 2.D Calculate the heat q absorbed or released by a system undergoing heating/cooling based on the amount of the substance, the heat capacity, and the change in temperature. | ENE – 2.D.2 The first law of thermodynamics states that energy is conserved in chemical and physical processes. |
| | ENE – 2.D.3 The transfer of a given amount of thermal energy will not produce the same temperature change in equal masses of matter with differing specific heat capacities. |
| | ENE – 2.D.4 Heating a system increases the energy of the system, while cooling a system decreases the energy of the system. |
| | ENE – 2.D.5 The specific heat capacity of a substance and the molar heat capacity are both used in energy calculations. |
| | ENE – 2.D.6 Chemical systems change their energy through three main processes: heating/cooling, phase transitions, and chemical reactions. |
| 6.5 Energy of Phase Changes | ENE - 2.E.1 Energy must be transferred to a system to cause a substance to melt (or boil). The energy of the system therefore increases as the system undergoes a solid-to-liquid (or liquid-to-gas) phase transition. Likewise, a system releases energy when it freezes (or condenses). The energy of the system decreases as the system undergoes a liquid-to-solid (or gas-to-liquid) phase transition. The temperature of a pure substance remains constant during a phase change. |
| ENE – 2.E Explain changes in the heat q absorbed or released by a system undergoing a phase transition based on the amount of the substance in moles and the molar enthalpy of the phase transition. | ENE – 2.E.2 The energy absorbed during a phase change is equal to the energy released during a complementary phase change in the opposite direction. For example, the molar heat of condensation of a substance is equal to the negative of its molar heat of vaporization. |
| 6.6 Introduction to Enthalpy of Reaction | ENE - 2.F.1 The enthalpy change of a reaction gives the amount of heat energy released (for negative values) or absorbed (for positive values) by a chemical reaction at constant pressure. |
| ENE – 2.F Calculate the heat q absorbed or released by a system undergoing a chemical reaction in relationship to the amount of the reacting substance in moles and the molar enthalpy of reaction | X - THE TECHNICAL DISTINCTIONS BETWEEN ENTHALPY AND INTERNAL ENERGY WILL NOT BE ASSESSED ON THE AP EXAM. Rationale: These distinctions are beyond the scope of the AP Chemistry course. Most reactions studied at the AP level are carried out at constant pressure. Under these conditions the enthalpy change of the process is equal to the heat (and by extension, the energy) of reaction. For example, in the AP Chemistry course the terms “bond energy” and “bond enthalpy” are often used interchangeably |
| 6.7 Bond Enthalpies | ENE - 3.A.1 During a chemical reaction, bonds are broken and/or formed, and these events change the potential energy of the system. |
| ENE – 3.A Calculate the enthalpy change of a reaction based on the average bond energies of bonds broken and formed in the reaction. | ENE – 3.A.2 The average energy required to break all of the bonds in the reactant molecules can be estimated by adding up the average bond energies of all the bonds in the reactant molecules. Likewise, the average energy released in forming the bonds in the product molecules can be estimated. If the energy released is greater than the energy required, the reaction is exothermic. If the energy required is greater than the energy released, the reaction is endothermic. |
| 6.8 Enthalpy of Formation | ENE - 3.B.1 Tables of standard enthalpies of formation can be used to calculate the standard enthalpies of reactions. EQN: $\Delta H^\circ_{\text{reaction}} = \sum \Delta H_f^\circ \text{ products} - \sum \Delta H_f^\circ \text{ reactants}$ |
| ENE – 3.B Calculate the enthalpy change for a chemical or physical process | |

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| based on the standard enthalpies of formation. | |
| 6.9 Hess's Law | ENE - 3.C.1 Although the concept of "state function" is not required for the course, two principles of Hess's law should be understood. First, when a reaction is reversed, the enthalpy change stays constant in magnitude but becomes reversed in mathematical sign. Second, when two (or more) reactions are added to obtain an overall reaction, the individual enthalpy changes of each reaction are added to obtain the net enthalpy of the overall reaction. |
| ENE – 3.C Represent a chemical or physical process as a sequence of steps. ENE – 3.D Explain the relationship between the enthalpy of a chemical or physical process and the sum of the enthalpies of the individual steps. | ENE – 3.D.1 When the products of a reaction are at a different temperature than their surroundings, they exchange energy with the surroundings to reach thermal equilibrium. Thermal energy is transferred to the surroundings from the products of an exothermic reaction. Thermal energy is transferred from the surroundings to the products of an endothermic reaction. |

7 – Equilibrium

~7 -9% exam weighting

| Topic & Enduring Understanding | Learning Objective | Essential Knowledge & Exclusion Statements |
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| 7.1 Introduction to Equilibrium | ENE – 2.B Represent a chemical or physical transformation with an energy diagram. | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |
| ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy. | | |
| 7.2 Direction of Reversible Reactions | ENE – 2.B Represent a chemical or physical transformation with an energy diagram. | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |
| ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy. | | |
| 7.3 Reaction Quotient and Equilibrium Constant | ENE – 2.B Represent a chemical or physical transformation with an energy diagram. | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |
| ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy. | | |
| 7.4 Calculating the Equilibrium Constant | ENE – 2.B Represent a chemical or physical transformation with an energy diagram. | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |
| ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy. | | |
| 7.5 Magnitude of the Equilibrium Constant | ENE – 2.B Represent a chemical or physical transformation with an energy diagram. | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |

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| <p>ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy.</p> | | |
| <p>7.6 Properties of the Equilibrium Constant</p> | <p>ENE – 2.B Represent a chemical or physical transformation with an energy diagram.</p> | <p>ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process.</p> |
| <p>ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy.</p> | | |
| <p>7.7 Calculating Equilibrium Concentrations</p> | <p>ENE – 2.B Represent a chemical or physical transformation with an energy diagram.</p> | <p>ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process.</p> |
| <p>ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy.</p> | | |
| <p>7.8 Representations of Equilibrium</p> | <p>ENE – 2.B Represent a chemical or physical transformation with an energy diagram.</p> | <p>ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process.</p> |
| <p>ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy.</p> | | |
| <p>7.9 Introduction to Le Chatelier's Principle</p> | <p>ENE – 2.B Represent a chemical or physical transformation with an energy diagram.</p> | <p>ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process.</p> |
| <p>ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy.</p> | | |
| <p>7.10 Reaction Quotient and Le Chatelier's Principle</p> | <p>ENE – 2.B Represent a chemical or physical transformation with an energy diagram.</p> | <p>ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process.</p> |
| <p>ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy.</p> | | |
| <p>7.11 Introduction to Solubility Equilibria</p> | <p>ENE – 2.B Represent a chemical or physical transformation with an energy diagram.</p> | <p>ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process.</p> |
| <p>ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy.</p> | | |

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| 7.12 Common-Ion Effect | ENE – 2.B Represent a chemical or physical transformation with an energy diagram. | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |
| ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy. | | |
| 7.13 pH and Solubility | ENE – 2.B Represent a chemical or physical transformation with an energy diagram. | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |
| ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy. | | |
| 7.14 Free Energy of Dissolution | ENE – 2.B Represent a chemical or physical transformation with an energy diagram. | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |
| ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy. | | |

8 – Acids and Bases

~11 -15% exam weighting

| Topic & Enduring Understanding | Learning Objective | Essential Knowledge & Exclusion Statements |
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| 8.1 Introduction to Acids and Bases | ENE – 2.B Represent a chemical or physical transformation with an energy diagram. | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |
| ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy. | | |
| 8.2 pH and pOH of Strong Acids and Bases | ENE – 2.B Represent a chemical or physical transformation with an energy diagram. | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |
| ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy. | | |
| 8.3 Weak Acid and Base Equilibria | ENE – 2.B Represent a chemical or physical transformation with an energy diagram. | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |
| ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy. | | |
| 8.4 Acid-Base Reactions and Buffers | ENE – 2.B Represent a chemical or physical transformation with | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |

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| | an energy diagram. | |
| ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy. | | |
| 8.5 Acid-Base Titrations | ENE – 2.B Represent a chemical or physical transformation with an energy diagram. | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |
| ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy. | | |
| 8.6 Molecular Structure of Acids and Bases | ENE – 2.B Represent a chemical or physical transformation with an energy diagram. | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |
| ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy. | | |
| 8.7 pH and pKa | ENE – 2.B Represent a chemical or physical transformation with an energy diagram. | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |
| ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy. | | |
| 8.8 Properties of Buffers | ENE – 2.B Represent a chemical or physical transformation with an energy diagram. | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |
| ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy. | | |
| 8.9 Henderson-Hasselbalch Equation | ENE – 2.B Represent a chemical or physical transformation with an energy diagram. | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |
| ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy. | | |
| 8.10 Buffer Capacity | ENE – 2.B Represent a chemical or physical transformation with an energy diagram. | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |
| ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy. | | |

9 – Applications of Thermodynamics**~7-9% exam weighting**

| Topic & Enduring Understanding | Learning Objective | Essential Knowledge & Exclusion Statements |
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| 9.1 Introduction to Entropy | ENE – 2.B Represent a chemical or physical transformation with an energy diagram. | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |
| ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy. | | |
| 9.2 Absolute Entropy and Entropy Change | ENE – 2.B Represent a chemical or physical transformation with an energy diagram. | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |
| ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy. | | |
| 9.3 Gibbs Free Energy and Thermodynamic Favorability | ENE – 2.B Represent a chemical or physical transformation with an energy diagram. | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |
| ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy. | | |
| 9.4 Thermodynamic and Kinetic Control | ENE – 2.B Represent a chemical or physical transformation with an energy diagram. | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |
| ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy. | | |
| 9.5 Free Energy and Equilibrium | ENE – 2.B Represent a chemical or physical transformation with an energy diagram. | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |
| ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy. | | |
| 9.6 Coupled Reactions | ENE – 2.B Represent a chemical or physical transformation with an energy diagram. | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |
| ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy. | | |
| 9.7 Galvanic (Voltaic) and Electrolytic Cells | ENE – 2.B Represent a chemical or physical transformation with | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |

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| | an energy diagram. | |
| ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy. | | |
| 9.8 Cell Potential and Free Energy | ENE – 2.B Represent a chemical or physical transformation with an energy diagram. | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |
| ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy. | | |
| 9.9 Cell Potential Under Nonstandard Conditions | ENE – 2.B Represent a chemical or physical transformation with an energy diagram. | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |
| ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy. | | |
| 9.10 Electrolysis and Faraday's Law | ENE – 2.B Represent a chemical or physical transformation with an energy diagram. | ENE - 2.B.1 A physical or chemical process can be described with an energy diagram that shows the endothermic or exothermic nature of that process. |
| ENE - 2 Changes in a substance's properties or change into a different substance requires an exchange of energy. | | |
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NOT FINISHED! This is a work in progress :-) I will keep adding to it as I have time.