

HONORS CHEMISTRY COURSE CONTENT OBJECTIVES

Unit 1: The Fundamentals: Matter and Measurement, Atoms, Molecules, and Ions

Content and/or Skills Taught ~ Students will:

- distinguish between physical and chemical properties and changes.
- understand the difference between elements, compounds, and mixtures.
- be familiar with the units of the metric system of measurement and the temperature scales.
- be able to convert measurements, especially within the metric system, by using dimensional analysis.
- determine the number of significant figures in a measurement and be able to express the results of a calculation with the proper number of significant figures.
- distinguish between protons, neutrons, and electrons, and be able to describe the composition of an atom of any particular element in terms of these subatomic particles.
- describe the basic anatomy of an atom and the ratio of the diameter of the nucleus to that of the atom.
- know the difference between an atom, an ion, and a molecule.
- have a basic knowledge of the periodic table, which includes being able to predict whether an element is a metal or a nonmetal, and what will be the probable charge of its ion.
- distinguish between empirical, molecular, and structural formulas.
- be able to write the correct name of an inorganic compound from its formula and vice versa.
- define hydrocarbon, alkane, and alcohol and be able to write the name from the formula and vice versa for simple alkanes and alcohols.

Unit 2: Chemical Reactions and Stoichiometry: Stoichiometry and Calculations with Chemical Formulas and Equations; Aqueous Reactions and Solution Stoichiometry

Content and/or Skills Taught ~ Students will

- be able to balance chemical equations.
- write balanced chemical equations from word descriptions.
- predict the products of reactions based on the types presented, including combustion of compounds of C, H, and O.
- complete and balance these reactions.
- predict the presence of a strong electrolyte, weak electrolyte, or nonelectrolyte based on the solubility rules, molecular substances and knowledge of strong and weak acids and bases.
- predict the ions that form from electrolyte dissociation.
- identify substances as acids, bases, or neutral salts.
- using solubility rules, predict soluble or insoluble products of a chemical reaction and write a balanced molecular, ionic and net ionic equation.
- predict the products and write a balanced chemical equation for neutralization reactions.
- after constructing molecular reactions for metathesis reactions, be able to identify spectator ions and write the net ionic equations.
- assign oxidation numbers to atoms.
- determine whether a reaction is redox.
- use the activity series to predict whether a redox (single replacement) reaction will occur, and be able to write the molecular and net ionic equations for a reaction.
- calculate the atomic weight (average atomic mass) of an element from the relative abundances and masses of its naturally occurring isotopes.
- calculate the percentage composition of a compound from its formula.
- calculate the molar mass of a substance from its chemical formula.
- be able to interconvert between moles, mass, and number of particles of a substance.
- calculate the empirical formula of a compound from either elemental percent composition or quantity of CO_2 and H_2O produced from its combustion.
- calculate the molecular formula of a compound from the empirical formula and molecular weight.
- find the mass of any substance in a chemical reaction from the mass of one substance.
- determine the limiting reactant (limiting reagent) in a reaction and then calculate the amount of each product and the mass and/or molarity of the excess reactant left over and ions remaining in solution.
- calculate theoretical yield.
- calculate moles of solute, volume of solution, or molarity of the solution given the other two values.
- recognize and solve dilution problems.
- calculate the volume of a certain molarity solution required to react with another solution of known molarity.
- calculate the mass of a substance that would be required to react with a given volume of a solution of

known molarity.

- calculate mass of solute or concentration of an unknown solution from titration data.

Unit 3: Thermochemistry and Thermodynamics

Content and/or Skills Taught ~ Students will

- understand the meaning of system, surroundings, and the universe.
- be familiar with the units of energy.
- recognize and understand the meaning of state function.
- define enthalpy, and explain the changes that occur when heat is transferred to or from the system at constant pressure.
- know what the sign of the enthalpy indicates about the reaction.
- be able to sketch an enthalpy (Potential Energy) diagram for reactions given their enthalpy changes.
- be able to calculate the amount of heat released or absorbed by a reaction, knowing the quantity of the reactants and the enthalpy of the reaction utilizing standard thermodynamic tables or standard enthalpy values.
- define heat capacity and specific heat (capacity).
- be able to solve calorimetry problems.
- state and apply Hess's Law of Constant Heat Summation in calculating enthalpies of reaction from enthalpies of other reactions.
- know the standard state of an element or compound.
- define and illustrate the meaning of standard enthalpy of formation.
- calculate the enthalpy change of a reaction using a table of standard enthalpies of formation.
- define entropy in terms of randomness or disorder

Unit 4: Electron Structure of Atoms, Periodic Properties of the Elements

Content and/or Skills Taught ~ Students will

- understand the relationships $c = \lambda \cdot \nu$ and $E = h \cdot \nu$.
- understand the concept of a quantized atom and its relationship to a line spectra of atoms.
- explain the concept of ionization energy.
- describe the Uncertainty Principle and its affect on atomic theory.
- understand the relationship $\lambda = h/mv$ and its effect on atomic theory.
- describe how quantum numbers define electron orbitals and their value limitations.
- describe the shapes of the orbital types (s, p, d, f).
- understand the concept of electron spin and how it relates to electron configuration.
- write the electron configuration both symbolically and as an orbital diagram for any element.
- be able to write electron configurations, especially valence configurations, for any element, using the periodic table with the knowledge of the s,p,d, and f blocks.
- describe the variations of atomic radii in the groups and periods on the periodic table and the underlying reasons for the variations.
- describe and explain the observed changes in successive ionization energies for a given atom.
- describe the variations in first ionization energies in the groups and periods on the periodic table and the underlying reasons for the variations.
- describe the variations in the electron affinities of the elements.
- understand the relationship between Electron Configurations and the Periodic Table.
- understand Periodic Relationships: Atomic Radii, Ionization Energy, Electron Affinity, and Oxidation State.

Unit 5: Chemical Bonding and Molecular Geometry

Content and/or Skills Taught ~ Students will

- be able to write the Lewis symbol for any atom.
- understand the energies involved in the formation of ionic bonds—ionization energy, electron affinity, and lattice energy.
- predict the formula of an ionic compound between representative elements using the octet rule, and the periodic table to predict an atom's probable valence.
- describe what happens to radius when an atom forms an ion.
- be able to explain the variation in size of an isoelectronic series.
- describe the nature of the covalent bond in terms of electron cloud overlap.
- be able to show covalent bond formation using Lewis symbols.
- be able to draw Lewis structures for bonds between atoms—single, double, and triple covalent.

- relate bond energies to bond order, bond length, formation and the favoring of low potential energy.
- explain electronegativity, how it varies on the periodic table, and its relationship to the nature of the bond between two atoms.
- predict the polarities of bonds between any two atoms from their electronegativities or their positions on the periodic table.
- write correct Lewis structures for any simple molecule or ion even when there is an exception to the octet rule.
- be able to write resonance structures when no one structure is adequate.
- relate the number of electron domains in the valence shell of an atom to the geometric arrangement of electrons around the atom.
- understand that the relative degree of repulsion between nonbonding pairs is greater than between bonding pairs of electrons.
- predict the molecular shape of a molecule or ion from its Lewis structure.
- predict, from its molecular shape and the electronegativities of the atoms involved, whether a molecule is polar (has a dipole).
- explain the types of hybridization.
- assign the type of hybridization on the basis of the electron geometry of the valence shell of an atom.
- describe the bonding between atoms in a molecule as sigma or pi.
- explain the concept of delocalization in pi bonds.
- describe how molecular orbitals are formed from atomic orbitals.

Unit 6: Gases

Content and/or Skills Taught ~ Students will

- describe properties of gases compared to other physical states.
- define common units of gas pressure.
- describe how gases respond to changes in V , n , P , and T .
- be able to solve problems using combined and ideal gas equations.
- be able to calculate molar mass from gas density and vice versa.
- calculate the partial pressure of any gas from the composition of its mixture.
- understand the process and calculation of the pressure of a gas collected over water.
- describe how the relative rates of diffusion and effusion of gases depend on their molar masses and densities.
- understand the kinetic molecular theory.
- be able to work through gas stoichiometry problems.
- understand how real gases deviate from ideal gases especially at high pressure and/or low temperature.

Unit 7: Intermolecular Forces, Liquids, and Solids, Properties of Solutions

Content and/or Skills Taught ~ Students will

- read, construct and interpret phase change diagrams.
- understand the kinetic molecular theory explanation of physical states.
- understand how vapor pressure depends on intermolecular attraction and temperature.
- define boiling point.
- calculate the amount of heat to change a substance from one temperature and state to another from the heat capacities and enthalpies of change of state.
- be able to use their knowledge of periodic trends to classify and predict the physical and chemical properties of an element.
- explain why "like dissolves like!"
- understand the effects of temperature and pressure on solubility.
- define units of concentration, mass percent, ppm, molarity, molality, and be able to calculate each from appropriate data.
- be able to convert a concentration from one unit to the other.

Unit 8: Chemical Kinetics

Content and/or Skills Taught ~ Students will

- explain graphically the concept of activation energy.
- explain how temperature and particle size/surface area affects reaction rate
- describe the theory of how a catalyst works and how it reduces the activation energy.

Unit 9: Chemical Equilibrium

Content and/or Skills Taught ~ Students will

- understand the meaning of dynamic equilibrium.
- write the equilibrium expression for any chemical reaction.
- understand the meaning of the magnitude of the value of K_{eq} .
- calculate K_{eq} when given appropriate data.
- explain how an equilibrium is shifted by stresses (changes in temperature, pressure, or concentration)—Le Chatelier's Principle.
- describe the effect of a catalyst on an equilibrium.

Unit 10: Acid-Base Reactions and Solution Equilibria

Content and/or Skills Taught ~ Students will

- list general properties that characterize acidic and basic solutions and the ions responsible.
- understand the Brønsted-Lowry theory and be able to identify conjugate acids and bases.
- explain the autoionization of water and write the K_w expression.
- define pH and be able to interconvert between $[H^+]$, $[OH^-]$, pH, and pOH.
- understand what is meant by strength of an acid or a base.
- given the acid concentration, be able to interconvert between K_a and pH. Given the base concentration, be able to interconvert between K_b and pH.
- calculate the concentration of each species in a solution formed by mixing an acid and a base.
- describe how a buffer solution works.

Unit 11: Redox Reactions and Electrochemistry

Content and/or Skills Taught ~ Students will

- identify redox reactions, the species oxidized, reduced, the oxidizing agent, and the reducing agent.
- balance redox reactions by using oxidation number method and half-reactions method.
- diagram and label electrolytic cells.
- describe and illustrate the direction of electron flow in an electrolytic cell.

Unit 12: Descriptive, Organic and Nuclear Chemistry

Content and/or Skills Taught ~ Students will

- identify simple patterns of chemical reactivity.
- predict the products of precipitation, acid/base and redox reactions.
- identify the basic properties and chemical behaviors of metals, nonmetals and metalloids
- identify periodic trends.
- identify types of hydrocarbons, major functional groups, structural isomers
- be able to write, balance and predict the products of nuclear reactions; natural and artificial transmutation and fission and fusion reactions.
- understand the application of carbon dating and the practical applications of nuclear chemistry.
- understand the meaning of half-life.