Chemistry Honors

Course Description

Chemistry is the science that studies the properties of matter and how these properties interact, combine, and change as a result of physical and chemical processes. This course is designed to give students a comprehensive introduction to chemistry concepts, scientific reasoning, and laboratory skills. Chemistry honors students will be challenged to understand topics to a high degree of detail and depth. Topics studied will include: properties of matter, atomic structure, the periodic table, chemical formulas, balancing equations, stoichiometry, acid/base chemistry, bonding and reactivity, and the behavior of electrons. This class has a significant laboratory component that encourages students to form and investigate hypotheses related to course content. As a part of the laboratory experience, students practice making precise measurements, following written protocols, making keen observations, analyzing data, interpreting results, and writing scientific papers to describe their experiments. This course teaches and reinforces dispositions and skills defined in the ***Portrait of the Crusader.*** Students learn to approach problems and situations with an open mind, use inquiry and innovation to solve problems, think critically about the information presented before responding with questions or feedback, and show respect for others' ideas.

Course Essential Questions

- How have advances in the study of chemistry changed our world?
- What are atoms, and how do they help us explain the behavior of matter?
- What is the relationship between matter and energy?
- What is a chemical reaction and what factors affect chemical reactions?
- How can we predict what chemicals will react with each other, and what the products will be?
- Why are some substances harmful and others safe?
- What tools and techniques do chemists use in the lab?
- What do the symbols and notation used by chemists mean?

Course Curriculum

<u>Q1, Unit 1: Mathematical Foundation</u>

Primary resource: Chapter 3 of *Pearson Chemistry*

Focus Questions:

- Why is accuracy and precision important to the science of chemistry?
- Why do scientists need a standardized, international system of measurement?
- How do we calculate percent error, and why is it important?
- What are the SI base units for measuring mass, energy, volume, mass, length, temperature, and time?
- What SI prefixes are important in chemistry?
- How do we convert between units of measurement? What is a conversion factor?
- What is scientific notation, and why is it important?
- What are significant figures/digits, and why are they important?
- What is absolute zero?

Concepts/Skills:

- Apply the concepts of precision and accuracy to measurements.
- Determine significant figures in measurements.
- Use the rules of significant figures to properly round calculations based on measurements.
- Convert between scientific notation and standard notation.
- Demonstrate an understanding of the true size of a number expressed in scientific notation.
- Explain what various SI units describe.
- Learn to include units when reporting measurements and calculations.
- Differentiate mass vs. weight.
- Define density.
- Use dimensional analysis to convert between units and solve density problems.
- Use metric devices, a triple beam, electronic and manual balances, and graduated cylinders.
- Apply concepts of accuracy, precision, and percent error to measurements made in the lab.

Laboratories:

- Accuracy, Precision, and Significant FiguresLab
- Density Lab

Assessments:

- Summer Packet
- Quizzes on scientific notation, significant figures, dimensional analysis
- Unit Test

Q1, Unit 2: Substances

Primary resource: Chapter 2 of *Pearson Chemistry*

Focus Questions:

- How do we classify matter based on its properties?
- What is a substance?
- What are mass and volume?
- What is the difference between an element, compound, and mixture?
- What are some techniques used to separate mixtures?
- What is the Law of Conservation of Mass?
- What is a physical property? Chemical property?
- What is the difference between a physical and chemical change?
- How do we define solids, liquids, and gasses?
- How are chemical symbols and formulas written?

Concepts/Skills:

- Classify substances as elements, compounds, or mixtures.
- Identify changes as physical or chemical.
- Classify mixtures as homogeneous or heterogeneous and propose methods for separating mixtures.
- Model and provide a comprehensive definition for the terms solid, liquid, and gas.
- Use the Law of Conservation of Mass to predict how much product will form in a reaction.

- Correctly write symbols for elements and some compounds.
- Define/describe four signs of a chemical change.

Laboratories:

- Physical and Chemical Changes Lab
- Separating Mixtures
- Electrolysis of Water

Assessments:

- Test
- Laboratory notes or Laboratory Report focused on selected sections.

Q1, Unit 3: Structure of Atoms

Primary resource: Chapter 4 of *Pearson Chemistry*
Focus Questions:

- What is the history of atomic theory? How does atomic theory help us explain the world?
- How are the atoms of each element different from each other?
- What are isotopes?
- What is atomic number?
- What is atomic mass (AKA atomic weight)?
- What is mass number?
- How do you calculate the atomic mass of an element?
- Where are the protons, neutrons, and electrons in an atom?
- What are the charges and relative masses of protons, neutrons, and electrons?
- What is an atomic mass unit, AKA Dalton?

Concepts/Skills:

- Use the periodic table to determine atomic number, atomic mass, and mass number of an element.
- Calculate the atomic mass of an element given the masses of isotopes and their relative abundance.
- Summarize the main points in the history of atomic theory.
- Model an atom showing protons, neutrons, and electrons.
- Distinguish between subatomic particles based on their charge, mass, and location.
- Distinguish between isotope, atom, atomic number, mass number.
- Use the mass number of an isotope to determine the number of neutrons.

Laboratory:

- Simulation of Rutherford's Gold Foil Experiment

Assessment:

- Test

Q2, Unit 4: Nuclear Chemistry

Primary resource: Chapter 25 of *Pearson Chemistry*

Focus Questions:

- Why are the nuclei of some atoms unstable?
- What makes an element radioactive? Which elements are always radioactive? Sometimes radioactive?
- What is nuclear radiation? What are the three main types?
- What is electromagnetic radiation, and when can it become dangerous?
- What is half-life, and what is it used for?
- How and why do nuclear reactors work?
- How does radiometric dating work?
- What do we need to know about radioactivity to keep ourselves safe in the modern world?

Concepts/Skills:

- Define the three types of nuclear radiation.
- Explain why some atoms emit radiation.
- Use the exponential decay formula to calculate how old a sample of an element is.
- Explain what half-life is.
- Contrast nuclear fission and fusion.
- Understand in simple terms how nuclear fission and fusion release enormous energy.
- Identify situations in which radiation hazards might occur.

Assessments:

- Research Project on technologies related to chemistry
- Test

Q2, Unit 5: Electrons and Light

Primary resource: Chapter 5 of *Pearson Chemistry*

Focus Questions:

- Why can't we determine the exact location of electrons in the atom?
- What is a quantum? What is quantum theory?
- What is an atomic orbital?
- What is an electron configuration, and why is it important?
- What happens when an electron goes to a higher energy level? When it drops back down?
- How many electrons can typically be found in the first, second, and third energy levels?
- What are the major divisions of the electromagnetic spectrum?
- How are the wavelength and frequency of EM radiation related?
- What is an atomic emission spectrum?
- What is a photon?

Concepts/Skills

- Identify and draw the shapes of atomic orbitals.
- Identify how many electrons are in an energy level.
- Understand an Aufbau diagram and use it to write electron configurations of elements.
- Write orbital filling diagrams for various elements.
- Explain the importance of electrons going up and down energy levels.
- Explain the applications of atomic emission spectra and gas discharge tubes.
- Calculate the wavelength or frequency of light given the other.
- Calculate the energy of a photon.
- Provide evidence that light is both a particle and a wave.

Laboratories:

- Flame Test Lab
- Atomic Emission Spectra Lab

Assessments:

- Laboratory Report
- Quiz on electron configurations and the quantum mechanical model
- Quiz on electromagnetic radiation, atomic emission spectra, and energy.
- Test

Q2, Unit 6: Periodic Table

Primary resource: Pearson *Chemistry* Chapter 6

Focus Questions:

- What information does the Periodic Table provide? How is the modern Periodic Table organized?
- What are the three broad classes of elements?
- What is a group on the periodic table? What is a period?
- What are the names of important groups of elements?
- How do the electron configurations of elements relate to their locations in the periodic table?
- What are some trends we can observe on the periodic table?

Concepts/Skills:

- Define: group, period, valence electrons.
- Use the American and International numbers for referring to groups.
- Identify an element's name, symbol, atomic number, atomic mass,and number of electrons in each energy level from the periodic table.
- Summarize the properties of metals, nonmetals, and metalloids.
- Identify the number of valence electrons in each representative group (groups 1-2, 13-18).
- Identify the alkali metals, alkaline earth metals, halogens, noble gasses, transition metals, and inner transition metals on the periodic table.
- Explain where the metals, nonmetals, and metalloids are on the periodic table.

- Explain what ions are and how they form.
- Differentiate cations from anions.
- Understand the periodic trends of atomic size, ionic size, electronegativity, and ionization energy.

Laboratories:

- Element Classification Lab
- Metal Reactivity Lab

Assessments:

- Test

Q3, Unit 7: Ionic and Metallic Bonding

Primary resource: Pearson *Chemistry* Chapter 7, Chapter 9.1 and 9.2
Focus Questions:

- What is a chemical bond?
- What force holds ionic bonds together?
- What is the importance of valence electrons in bonding?
- How do we interpret an electron dot structure?
- What are the general properties of ionic compounds?
- What is the octet rule?
- What are the general properties of ionic compounds?
- What is metallic bonding?
- How do we name ionic compounds?

Concepts/Skills:

- Define valence electrons, formula unit, molecule, electrolyte, coordination number, alloy
- Explain the octet rule and use it to predict what compounds will form.
- Understand why transition metals do not follow the octet rule.
- Draw electron dot structures for elements, ions, and compounds.
- Describe how and why cations and anions are formed.
- Explain why ionic compounds are electrically neutral.
- Use ionic charges to predict the formulas of ionic compounds.
- Predict the charge of an ion based on the location of the element in the periodic table.
- Write the names of ionic compounds when given the formulas, and vice versa.
- Explain how the high mobility of electrons determines the properties of metals.
- Identify the three main crystal structures of metals.

Laboratories:

- Salt Solutions Lab
- Making crystals
- Electrolytes Lab

Assessments:

- Lab Report
- Ionic compound naming quiz
- Test

Q3, Unit 8: Covalent Compounds

Primary resource: Pearson *Chemistry* Chapter 8, Chapter 9.3
Focus Questions:

- How is a covalent bond different from an ionic bond?
- How are covalent bonds drawn in structural formulas?
- What is the purpose of VSEPR Theory?
- What are the names of common molecular geometries?
- What does it mean for a molecule to be polar?
- How do the properties of molecules differ from those of ionic compounds?
- What's the difference between single, double, and triple bonds?
- What is bond dissociation energy?
- What are intermolecular forces?
- How do we name covalent compounds?

Concepts/Skills:

- Define: molecule, resonance structure, coordinate covalent bond, polyatomic ion
- Use bond dissociation energies to compare the strength of bonds.
- Contrast ionic bonds and covalent bonds.
- Distinguish sigma bonds and pi bonds, and identify when each will form.
- Predict whether an ionic or covalent bond will form from two or more elements.
- Draw Lewis structures (AKA structural formulas) of molecules.
- Recognize five of the common molecular shapes.
- Use VSEPR theory to predict the shapes of molecules.
- Using an electronegativity table, identify bonds as polar or nonpolar.
- Differentiate intermolecular from intramolecular forces.
- Use theories of intermolecular forces to explain states of matter and viscosity.
- Name covalent compounds based on their formulas.

Laboratories:

- Molecule Modeling Activity
- Chromatography Lab

Assessments:

- Quiz on Lewis structures
- Test

Q3, Unit 9: Moles

Primary Resource: Pearson *Chemistry* Chapter 10

Focus Questions:

- What is a mole, in chemistry?
- Why do chemists use moles?
- How can we convert between moles and mass, or volume?
- What is a representative particle?
- How many representative particles are in a mole?
- How do we determine the percent composition by mass of a compound, given its chemical formula?
- How do we determine the percent composition by mass experimentally?
- What does molarity mean, when we're dealing with solutions?

Concepts/Skills:

- Use molar mass to convert between grams and moles.
- Use molar volume to convert between liters and moles.
- Use Avogadro's Number to convert between moles and representative particles.
- Determine percent composition from a chemical formula, and vice versa.
- Use molarity (moles per liter) to create solutions of known concentrations.

Laboratories:

- Mole Calculation Lab
- Percent Composition of a Hydrate Lab

Assessments:

- Laboratory Report
- Quizzes on mole conversions and percent composition
- Test

Q3, Unit 10: Chemical Reactions

Primary resource: Pearson *Chemistry* Chapter 11

Focus Questions:

- How does the Law of Conservation of Mass relate to chemical reactions?
- How do you predict the products that will form in a chemical reaction?
- How do you write and balance a chemical equation?
- What are the five basic types of chemical reactions?
- How can we predict whether or not a chemical reaction will occur?
- What is a catalyst?
- How do we indicate the states of reactants and products in a chemical equation?

Concepts/Skills:

- Analyze the Law of Conservation of Mass and how this law relates to chemical reactions and balanced equations. Explain that a balanced equation represents conservation of atoms.
- Translate an English sentence into a chemical equation and vice versa.
- Progress from a skeleton equation to a balanced equation.
- Define the terms: catalyst, skeleton equation, aqueous, spectator ion, activity series.
- Write a complete and a net ionic equation.
- Predict when a precipitate will form.
- Classify reactions as single replacement, double replacement, decomposition, combination, or combustion.
- Predict when one element will or will not replace another.

Laboratories:

- Classifying Chemical Reaction Lab
- Dissolving Metals in Acid

Assessments:

- Quiz on balancing equations
- Post Lab Question and Answer Set
- Test

Q4, Unit 11: Stoichiometry

Focus Questions:

- What is a mole ratio?
- What is stoichiometry, and why is it important?
- How does the Law of Conservation of Mass relate to stoichiometry?
- How can you predict how much of a product will be formed in a reaction?
- How can you determine how much of a reactant is necessary to form the desired product?
- What is a limiting reagent? Excess reagent?
- How can you determine the limiting and excess reagents?
- What is theoretical yield?
- How do you calculate percent yield?

Concepts/Skills:

- Write molar ratios
- Recognize that the coefficients can be used to determine mole ratios in a reaction.
- Use molar ratios and the Law of Conservation of Mass to determine how many moles of a reactant/product will be involved in a reaction.
- Use the molar ratio as a go-between for different substances in an equation.
- Use the mass or volume of a reactant to predict the mass or volume of a product, and vice versa.
- Determine which reactant is limiting and which is(are) in excess.

Laboratory:

- Percent Yield Lab(s)

Assessments:

- Laboratory Report
- Test

Q4, Unit 12: Gasses

Focus Questions:

- How can the kinetic theory be used to understand gasses?
- What is the relationship between temperature, pressure, and volume of a gas?
- What are the separate and combined forms of the gas laws?
- What is the ideal gas constant, and how was it determined?
- What is the ideal gas law, and what can it be used for?
- Do real gasses approximate the behavior of ideal gasses? When do they deviate?
- What are partial pressures?
- What is Dalton's law of partial pressures?
- What factor affects the diffusion and effusion of gasses?

Skills/Concepts:

- Explain how gasses are different from solids and liquids.
- Use kinetic theory to explain the behavior of gasses.
- Predict what will happen to the volume and temperature of a gas if you increase the pressure.
- Predict what will happen to the pressure and volume of a gas if you increase the temperature.
- Use the combined gas law to predict how changes in two variables of a gas will affect the third variable.
- Use the ideal gas law to predict temperature, volume, pressure, or moles of a gas.

Laboratory:

- Gas Law Constant Lab

Assessments:

- Laboratory Report
- Test

Q4, Unit 13: Acids and Bases

Focus Questions:

- How can you identify an acid or a base?
- What are the Arrhenius definitions of acids and bases?
- What is a hydronium ion? A hydroxide ion?
- What are some common acids and bases, and where do we encounter them in daily life?
- What is the Bronsted-Lowry definition of acids and bases?

- What are conjugate acids and bases?
- What is an amphoteric substance?
- What is the Lewis definition of acids and bases?
- What does pH stand for?

Concepts/Skills:

- Define: acid, base, pH, ion-product constant for water, hydronium, amphoteric, conjugate acid/base.
- Identify compounds as acids and bases.
- Differentiate between Arrhenius acids/bases and Bronsted-Lowry acids/bases.
- Predict the conjugate acids/bases that will be formed when an acid/base reacts with water.
- Define an amphoteric substance.
- Define a Lewis acid/base.
- Identify when a substance fits one, two, or all three definitions of an acid/base.
- Identify whether a solution is acidic or basic from its pH.
- Calculate the pH of a solution from its concentration of protons and vice versa.
- Use indicators to measure pH of a solution.
- Identify strong and weak acids, and explain what makes an acid strong or weak.

Laboratories:

- Titration Lab
- pH Lab

Assessments:

- Laboratory Report
- Test

Q4, Unit 15: Reaction Rates and Equilibrium

Focus Questions:

- What is activation energy, and what are some examples of it?
- How does collision theory explain the rates of reactions?
- What factors can affect the rates of reactions?
- What is the relationship between catalysts and activation energy?
- What are rate laws, and how can they be applied?
- What do we mean by the “order of a reaction”?
- Do all chemical reactions occur in a single step?
- What is the rate-determining step of a multistep reaction?
- What does a double arrow indicate in a chemical equation?
- Why does equilibrium occur in certain chemical reactions?

Concepts/Skills:

- Interpret graphs showing activation energy barriers.
- Predict whether the rate of reaction will increase or decrease when certain variables are manipulated.
- Explain why a catalyst speeds up the rate of a reaction.
- Define: rate law, specific rate constant, activation energy, catalyst, first order reaction, chemical equilibrium, equilibrium constant
- Explain the order of a reaction and how it is calculated.
- Understand that most chemical reactions take place in several steps via intermediates.
- Explain what chemical equilibrium really means, and how it relates to concentrations and reaction rates.
- Identify reversible and irreversible reactions.
- Predict how adding or removing reactants or products will affect the equilibrium of a reaction.
- Calculate the equilibrium constant

Laboratory:

- Activation Energy Lab

Assessments:

- Laboratory Report
- Test

Grading Policy

- Tests: 40-50 %
- Quizzes: 15-20%
- Laboratory related: 15-20%
- Homework/Classwork: 15-25%

The **Late Policy** is determined at the department evel and is the same for all courses in the department.