Miami Dade College

Course Description

CHM1045 | General Chemistry and Qualitative Analysis | 3.00 credits

This course is designed for students pursuing careers in the sciences or who need a more rigorous presentation of chemical concepts than is offered in an introductory course. Students will engage in problem solving and critical thinking while applying chemical concepts. Topics will include the principles of chemistry including atomic theory, electronic and molecular structure, measurement, stoichiometry, bonding, periodicity, thermochemistry, nomenclature, solutions, and the properties of gases. Student learning outcomes: students will apply the law of conservation of matter and energy; students will implement rules of significant numbers to all measurements; students will explain the fundamental properties of matter including but not limited to atomic and electronic structure, and periodicity; students will apply IUPAC rules of nomenclature; students will predict molecular geometry and properties from bonding theories; and students will predict and explain the products of chemical reactions (e.g., acid-base, oxidation-reduction, precipitation, dissociation). Prerequisite: CHM1025 or a passing score on the CART exam, MAC1105. Co-requisite: CHM1045L.

Course Competencies

Competency 1: The student will demonstrate knowledge of the basic units, calculations, conversions, and measurements by:

1. Applying the concept of significant figures and rounding off.
2. Converting among the three common temperature scales.
3. Performing density calculations.

Competency 2: The student will demonstrate knowledge of properties, changes, and the basic building blocks of matter by:

1. Characterizing the three common states of matter, how the interconversion among states can occur, and the terminology employed during interconversion.
2. Applying the Law of Conservation of Matter.
3. Defining isotopes and determining how the properties and structure of isotopes of a single atom differ.
4. Relating an element's isotopic abundance and mass to its average atomic mass
5. Identifying the number of protons, neutrons, electrons, mass number, and atomic number an atom has given its isotope symbol.
6. Recalling the name and symbol of common elements and describing their nature.
7. Illustrating how an ion is formed from its parent atom and learning the name and formula of common ions.
8. Showing how atoms or ions combine to form compounds.
9. Identifying the basic repeating unit of elements (atom, molecule, or formula unit), ions (ion or formula unit), and compounds (molecule or formula unit).

Competency 3: The student will demonstrate knowledge of the periodic table by:

1. Identifying an element's atomic symbol, atomic number, and atomic mass.
2. Differentiating the structure of the periodic table in terms of groups and periods; classifying elements as metals, on-metals, or metalloids; and according to their group's name as noble gases, alkali metals, alkaline earth metals, or halogens. Distinguishing among main-group elements, transition elements, and inner transition elements.
3. Describing the pattern of common periodic properties such as atomic radii, ionic radii, ionization energy, electron affinity, metallic character, and electronegativity.
4. Relating an element's group number to its number of valence electrons and the ion that it commonly forms.
5. Identifying the periodic table's s, p, d, and f blocks.

Competency 4: The student will demonstrate knowledge of electronic structure by:

1. Manipulating the relationship between the wavelength, frequency, and energy of electromagnetic radiation.
2. Applying the Rydberg equation to understand electronic transitions for the hydrogen atom.

3. Comparing and contrasting the particle and wave description of light.
4. Relating important advances in atomic theory, such as the quantization of energy to electronic emission and absorption spectra.
5. Identifying the basic concepts involved in the quantum mechanical model of the atom, such as the quantization of the energy levels, orbitals, and quantum numbers.
6. Generating a viable set of four quantum numbers associated with an electron.
7. Stipulating the maximum number of electrons that can be accommodated in the various principal energy levels, sublevels, and orbitals.
8. Generating the spectroscopic electronic configuration of elements and ions.
9. Relating the number of paired or unpaired electrons in a species to their diamagnetism or paramagnetism.
10. Recognizing the shape of s, p, and diatomic orbitals.
11. Applying Pauli's Exclusion Principle and Hund's Rule of Maximum Multiplicity to construct electronic orbital diagrams.
12. Stipulating the number of valence electrons in an atom.
13. Relating electronic configurations to the position of elements in the periodic table.

Competency 5: The student will demonstrate knowledge of chemical bonding by:

1. Predicting the type of bond that a compound will form from its constituent elements.
2. Relating the type of bond with the electronegativity differences of the elements involved in bonding.
3. Comparing and contrasting the differences between ionic and covalent bonding.
4. Writing the Lewis electron dot structure of elements, ions, ionic compounds, and covalent compounds. Recognizing exceptions to the octet rule.
5. Identifying when resonance structures are possible and how they relate with experimental bond lengths.
6. Calculating the formal charge for atoms involved in a covalent bond, and applying them to identify the best Lewis structure.
7. Using the Valence Shell Electron-Pair Repulsion Theory to determine molecular geometry and bond angles.
8. Predicting the relationship between molecular geometry and molecular polarity.
9. Using Valence Bond Theory to analyze the hybrid orbitals used in bonding and to describe double and triple bonds.
10. Using Molecular Orbital Theory to describe the type of bonding involved in homonuclear diatomic molecules or ions and how this theory is used to predict bond order, bond stability, paramagnetism, and diamagnetism.

Competency 6: The student will demonstrate knowledge of compositional stoichiometry by:

1. Identifying what atoms are present in a compound and in what ratio.
2. Calculating the molar mass of a substance from the sum of its atomic masses.
3. Demonstrating the ability to convert among moles, mass, and number of atoms, molecules or formula units in a given sample.
4. Showing how to find the mass percent of an element in a given compound.
5. Determining the empirical formula of a compound from elemental masses, mass percentages, or combustion analysis data.
6. Determining the molecular formula of a compound given its empirical formula, molar mass or information from which the molar mass can be determined.

Competency 7: The student will demonstrate knowledge of chemical reactions in relation to reaction stoichiometry by:

1. Balancing chemical reactions.
2. Solving stoichiometry problems.
3. Determining the limiting reactant in a stoichiometry problem when given two (or more) reactant amounts.
4. Using the limiting reagent concept in calculations with chemical equations to determine the amount of product formed.
5. Comparing the amount of substance actually formed in the reaction (actual yield) with the predicted amount (theoretical yield) to determine the percent yield of a chemical reaction.

Competency 8: The student will demonstrate knowledge of several aspects of solutions by:

1. Distinguishing between a solute and solvent in a solution.
2. Distinguishing among the different types of solutions: saturated, unsaturated, and supersaturated.
3. Writing the concentration of a solution in terms of mass percent, and show how to calculate it.
4. Writing the concentration of a solution in terms of molarity and show how to calculate it.
5. Using balanced equations to solve solution stoichiometry problems.
6. Calculating the concentration of a solution made by dilution of a stock solution.
7. Explaining how to prepare a diluted solution.

Competency 9: The student will demonstrate knowledge of writing chemical formulas and the chemical nomenclature of inorganic compounds by:

1. Determining the oxidation number of elements in a chemical formula.
2. Identifying different types of compounds.
3. Generating the name of ionic compounds or writing its formula when its name or constituent ions is given. This includes ions with a fixed oxidation number (Type I metals), ions with multiple oxidation numbers (Type II metals) as well as polyatomic ions.
4. Generating the name of molecular compounds or writing their formula when its name or constituent atoms are given.
5. Generating the name of binary or pseudo-binary acids or writing their formula when their name or constituent atoms are given.
6. Generating the name of common polyatomic ions or writing its formula when its name is given.
7. Generating the name of oxy acids or writing its formula when its name or constituent ions is given.

Competency 10: The student will demonstrate knowledge of several aspects involved in chemical reactions by:

1. Categorizing chemical reactions include ionization, dissociation, combustion, decomposition, single replacement, double replacement, synthesis, neutralization, precipitation, gas evolution, and oxidation-reduction reactions.
2. Using solubility rules to predict whether or not a chemical reaction will occur.
3. Using activity series (electromotive series) to predict whether or not a chemical reaction will occur.
4. Interpreting the solubility rules as a means to determining the physical state of substances involved in aqueous chemical reactions and as a means to determining the type of electrolytes a substance contains.
5. Completing and balancing chemical reaction equations.
6. Writing chemical equations of substances in aqueous solution in molecular, ionic, and net ionic form.
7. Determining whether a species involved in an oxidation-reduction reaction is being reduced or oxidized.
8. Categorizing reagents involved in oxidation-reduction reactions as reducing or oxidizing agents.

Competency 11: The student will demonstrate knowledge of gases and their properties by:

1. Comparing and contrasting the properties of gases to those of liquids and solids.
2. Determining the qualitative and quantitative relationship among pressure, volume, temperature, and amount of gas (Boyle's Law, Charles 'Law, Avogadro's Law, and Combined Gas Laws).
3. Using the Ideal Gas Equation in solving gas law problems.
4. Calculating gas densities and standard molar volumes.
5. Determining molar masses and formula of gaseous substances from measured properties of gases.
6. Describing how mixtures of gases behave and how Dalton's Law is used to solve problems involving a mixture of gases.
7. Using the kinetic-molecular theory of gases to demonstrate how this theory is consistent with the observed gas laws.
8. Describing molecular motion, diffusion, and effusion of gases.

Competency 12: The student will demonstrate knowledge of the properties of aqueous solutions of acids and bases by:

1. Identifying the factors responsible for making gases deviate from ideal behavior.
2. Performing calculations involving gas stoichiometry.
3. Comparing and contrasting the acid-base theories (Arrhenius, Brønsted-Lowry, and Lewis).

4. Describing properties of acids and bases.
5. Categorizing substances such as Arrhenius, Brønsted - Lowry, and Lewis acids/bases.
6. Identifying acid-base conjugate pairs in an acid-base reaction.

Competency 13: The student will demonstrate knowledge of thermodynamics by:

1. Predicting strengths of acids and bases.
2. Describing the leveling effect of water in the prediction of the strengths of acids and bases.
3. Distinguishing between state functions and path-dependent functions.
4. Outlining the difference between systems, surroundings, and the universe.
5. Calculating the change in enthalpy for physical or chemical processes from standard molar heat of formation data.
6. Using Hess' Law to calculate the change in enthalpy for a reaction.
7. Calculating the change in enthalpy by using bond energies.
8. Calculating the specific heat capacity of various substances.

Learning Outcomes

- Use quantitative analytical skills to evaluate and process numerical data