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Representing Alabama's Public Two-Year College System

Alabama
Department of
Postsecondary Education

Jefferson State Community College

CHM 111

College Chemistry I

I. CHM 111, College Chemistry I, 4 Semester Hours

Core Area III, ASCI TSCI (Lec 3 hrs, Lab 2 hrs) (***State guide has 3HR Labs)

II. Course Description

This is the first course in a two-semester sequence designed for the science or engineering major who is expected to have a strong background in mathematics. Topics in this course include measurement, nomenclature, stoichiometry, atomic structure, equations and reactions, basic concepts of thermochemistry, chemical and physical properties, bonding, molecular structure, gas laws, kinetic-molecular theory, liquids and solids, solutions, and colloids. Lab is required.

III. Prerequisite: MTH 112 (Precalculus Algebra) or equivalent math placement score.

IV. Textbook

General Chemistry. Ebbing & Gammon. 10th edition. Brooks/Cole.

V. Course Competencies

In the classroom the student will:

A. Understand the basic mathematical principles involved in chemical calculations and will have a thorough understanding of the metric system of measurement.
B. Understand the classification of matter into various groups based upon similarity of chemical and physical properties.
C. Comprehend and interpret chemical symbols, formulas, names, chemical equations, and calculations that apply, stressing stoichiometry.
D. Understand the electronic arrangement of the atom in terms of the quantum theory, and will be able to use the periodic table to link electronic configuration to the properties of the element.
E. Understand chemical periodicity.
F. Understand the nature of covalent bonding, ionic bonding, and the main concepts of the three covalent bonding theories (VB, VSEPR, MO).
G. Comprehend and apply the principles of gas behavior in ideal as well as real gas systems.
H. Understand the characteristics of the solid and liquid states of matter and phase diagrams.
I. Understand terms used in solution chemistry.
J. Understand the nature of aqueous solution systems and apply the principles of solubility, colligative properties and concentration in problem solving.
K. Understand and apply chemical principles of acids and bases.

In the laboratory the student will:

A. Develop an understanding of basic laboratory techniques and procedures.
B. Understand basic laboratory safety and will follow all laboratory rules during experimental work.
C. Acquire understanding of the physical and chemical properties of commonly used elements, compounds and mixtures.
D. Be able to make precise measurements and evaluate experimental data through selected qualitative laboratory experiments.
E. Be able to make careful observations, report and interpret experimental data through selected quantitative laboratory experiments.
F. Be able to perform simple calculations from experimental data through selected quantitative laboratory experiments.

VI. Course Outline of Topics

Lecture Topics Stated in Performance Terms

The student will be required to demonstrate that he has attained each general course competency by performing the objectives listed under each competency.

A. Understand the basic mathematical principles involved in chemical calculations, and will have thorough understanding of the metric system of measurement.

1. Express any given number in exponential notation, and use exponential notation in calculations.
2. Apply the rules of significant figures to calculations based upon experimental measurements.
3. Cite from memory the meaning of all metric prefixes listed in a reference table.
4. Cite from memory at least one conversion factor from reference table relating metric and English units of (a) mass, (b) length, and (c) volume.
5. Use dimensional analysis to convert within the metric system and between metric and non-metric units.
6. Carry out calculations relating density, specific gravity, mass, and volume to one another from assigned problems.
7. Convert a specified temperature in degrees Celsius, Fahrenheit or Kelvin to the other two scales.
8. Carry out calculations relating heat capacity or specific heat to the heat transfer that accompanies temperature changes.

B. Understand the classification of matter into various groups based upon similarity of chemical and physical properties.

1. State the Law of Conservation of Matter, the Law of Conservation of Energy, and the Law of Matter and Energy.
2. Express these Laws in words other than those used in the text and give an example of each.
3. Describe and distinguish among the general properties of gases, liquids, and solids.
4. Define and give examples of each: a chemical change, a physical change, a chemical property, a physical property, an intensive property, and extensive property, an endothermic change and exothermic change.
5. Define, distinguish among, and give an example of: a pure substance, a compound, a mixture, an atom, an element and molecule.
6. Distinguish between: mass and weight; density and specific gravity, accuracy

and precision, heat and temperature.

C. Comprehend and interpret chemical symbols, formulae, names, chemical equations, and calculations that apply, stressing stoichiometry.

1. Memorize the names and symbols of the elements given in a reference table.
2. Interpret a chemical formula in terms of the type and number of atoms present.
3. Given an ionic or molecular formula, determine the formula weight.
4. Relate the numbers of particles (atoms, molecules, or ions) and the mass in grams of a sample of matter.
5. Given the formula of a substance, relate the number of moles and the mass in grams of the sample.
6. Write and interpret the formulas for some common substances.
7. Given the formula of a compound, calculate the percentages by mass of the elements.
8. Determine the empirical formula of compound, given the mass percentages of the elements or the analytical data from which these can be calculated.
9. Determine the molecular formula of a compound, given the simplest formula and at least an approximated molecular mass.
10. Use the Periodic Table to obtain the charges of ions formed by the main-group elements.
11. Write the formula for an ionic compound given either the formulas of the ions or the name of the compound.
12. Given the formula for a compound, give its name.
13. Describe some experimental methods of determining percent composition.
14. Write and balance chemical equations and interpret the various symbols used in chemical equations to represent the condition of the reaction system.
15. Relate the number of moles of any two substances taking part in a reaction.
16. Relate the masses of any two substances taking part in a reaction.

17. Given or having calculated two of the three quantities, concentration, number of moles of solute, volume of solution, determine the other quantity.

18. Given the balanced equation for a reaction involving species in solution, relate the volumes or concentrations of two reactant species.

19. Describe water solution reactions involving precipitation, acid-base, and oxidation-reduction.

20. Given the number of moles or masses of all reactants, determine which is the limiting reagent and calculate the theoretical yield of any product.

21. Calculate the percent yield, given the actual or theoretical yields.

D. Understand the electronic arrangement of the atom in terms of quantum theory, and will be able to use the periodic table to link electronic configuration to the properties of the elements.

1. State and describe the postulates of quantum theory and compare quantum and classical theories.

2. Relate the wavelength and frequency of a spectral line to the energy of photons and to the change in energy of an atom.

3. Discuss the contributions to the atomic theory made by Dalton, Thomson, Rutherford, Bohr, Chadwick, deBroglie and Schrodinger.

4. State and apply the Aufbau principle.

5. Determine the number of electrons that may be accommodated by any given principal energy level or sublevel.

6. Given the atomic number of an element, write the electron configuration.

7. Given the electron configuration, state and apply Hund's rule and draw orbital diagram of the atom.

8. Describe the four quantum numbers, and the rules for assigning them.

9. Apply the rules and assign them to each of the various electrons in an atom.

10. State and apply Pauli's Exclusion principle.

11. Relate electronic configurations to the periodic table and to periodicity.

12. Using the periodic table, predict the relative values of ionization energy,

electronegativity, atomic radius, and ionic radius.

E. Understand chemical periodicity.

1. Describe what is meant by periodicity.

2. Relate the electronic configuration of an atom to the position of the element in the periodic table.

3. Categorize elements according to alkali metals, representative elements, chalcogens, alkaline earth metals, halogens, d-transition elements, noble gases, lanthanide series, actinide series, inner transition elements and f-transition elements.

4. Summarize horizontal and vertical trends in the periodic table for each of the following properties: atomic radii, electron affinity, ionization energy, ionic radii and electronegativity.

5. State the contrasting physical and chemical properties of metals and non-metals.

6. Know where the metals, nonmetals, and metalloids are located in the periodic table.

F. Understand the nature of covalent bonding, ionic bonding and the main concepts of the three covalent bonding theories (VB, VSEPR, MO).

1. Distinguish between the major aspects of ionic and covalent bonding.

2. Identify some of the major differences in physical properties of ionic and covalent compounds.

3. Predict whether bonding between a given pair of elements or in a given compound would be covalent or ionic.

4. Predict the formulas of binary ionic compounds from the positions of the constituent.

5. Given a periodic table, predict and compare bond polarity.

6. Draw Lewis structures for molecules and polyatomic ions.

7. Given or having written the Lewis structure of a molecule or ion, predict its geometry.

8. Predict molecular polarity from Lewis structures.
9. Predict molecular geometry from orbital hybridization.
10. Predict the kind and number of sigma and pi bonds in a molecular species.
11. Write molecular orbital diagrams for simple diatomic species.

G. Comprehend and apply the principles of gas behavior in ideal as well as real gas systems.

1. Describe and apply Boyle's, Charles', Gay-Lussac's and Avogadro's law.
2. Apply the ideal gas law to predict the effect of a change in conditions upon a variable such as volume.
3. Apply gas laws to calculate the density of a gas at a given temperature and pressure.
4. Use the ideal gas law to calculate the molecular mass of a gas, knowing the mass of a given volume or the density at a known pressure and temperature.
5. Relate volumes of gases involved in chemical reactions from information obtained from chemical equations.
6. Apply Dalton's law of partial pressures of gases in mixtures.
7. List the assumptions of kinetic-molecular theory and describe gas behavior in terms of the theory.
8. Describe and apply Graham's law to relate molecular masses, rates of effusion, and times of effusion of gases.
9. Describe how real gases deviate from the assumptions of the ideal gas law, and indicate the conditions where these deviations are most significant for most gases.

H. Understand the characteristics of the solid and liquid states of matter and phase diagrams.

1. Determine vapor pressure of liquids in given temperatures and pressures.
2. Predict and describe the various intermolecular forces present in molecular substances.

3. Classify a given substance as ionic, nonpolar, polar, macromolecular, or metallic.

4. List the general physical properties associated with each of the five categories of substances listed above.

5. Write equations for the thermal decomposition of carbonates, hydroxides, and hydrates.

6. Determine enthalpy change associated with a given phase change.

7. Interpret phase diagrams and apply them to predict phase changes associated with changes in temperature and pressure.

I. Understand terms used in solution chemistry.

1. Describe and distinguish among solvent, solute, solution, dispersion and colloid.

2. Give examples of various kinds of solutions involving different combinations of solids, liquids, and gases as dispersing medium and dispersed substances

3. Describe the relative effects on solubility of the following kinds of interactions: solute-solute; solvent-solvent; solvent-solute.

4. Describe and illustrate the mechanism of dissolution of ionic solids and polar covalent substances in water.

5. State the effects of exo- or endothermicity and of an increase in disorder on the spontaneity of the dissolution process.

6. Distinguish among unsaturated, saturated, and supersaturated solutions.

7. Distinguish between exothermic and endothermic dissolution process.

J. Understand the nature of aqueous solution system and apply the principles of solubility, colligative properties and concentration in problem solving.

1. Given the formula for a substance, predict whether it will be an electrolyte or a non-elecrolyte in aqueous solution.

2. Predict the relative solubilities of different solutes in water.

3. Predict the effect on solubility of a change in temperature or pressure.

4. Given a molecular, write the corresponding total and net ionic equations.

5. Using the solubility rules, predict whether two soluble ionic compounds will react to form a precipitate; if they will, write the net ionic equation.

6. Utilizing an equation for a precipitation reaction, relate the mole relationship of reactants and products.

7. List the colligative properties of solutions and state on what factors they depend.

8. Use the colligative properties to determine the molecular weights of solutes.

9. Applying Raoult's law, calculate the vapor pressure of a solution.

10. Applying Henry's law, given data for one set of conditions, determine the concentration of a gas in solution at a second set of conditions.

11. Perform calculations related to molarity, normality, mole fraction, and mass percent;

12. Perform calculations related to molarity and colligative properties.

L. Understand and apply chemical principles of acids and bases.

1.Describe the similarities and differences among the Arrhenius, Bronsted-Lowry, and Lewis theories of acids and bases.

2.Classify any given species in a reaction as an acid or base, according to acid-base pairs.

3. Describe the nature of the proton in aqueous solution, with special attention to the hydronium ion, H_3O^+.

4. Name the common strong acids and bases.

5. Write equations for the dissociation of strong acids or strong bases.

6. Write equations for the ionization equilibria of weak acids and weak bases in aqueous solutions.

7. Write equations for the reactions of acids and bases, describe the solutions that result as acidic, basic or neutral.

8. Describe the ionization of a poly-protic acid in aqueous solutions.

9. Predict the relative strengths of acids and bases from a given set of molecular structures.

10. Use titration data for an acid-base reaction to determine: the concentration of an acid or a base in aqueous solutions, and molecular mass of an acid or a base.

11. Select an acid-base indicator appropriate for a given acid-base titration.

12. Given the following $[H^+]$, $[OH^-]$, pH, or pOH calculate any of the others.

Laboratory Topics

A. The student will develop an understanding of basic laboratory techniques and procedures.

1. Properly operate the Bunsen burner.
2. Operate a single pan balance.

B. The student will understand basic laboratory safety and will follow all laboratory rules during experimental work.

1. Follow basic laboratory safety rules as set forth by the department and the instructor.
2. Locate laboratory safety and first aid equipment.

C. The student will acquire understanding of the physical and chemical properties of commonly used elements, compounds, and mixtures.

1. Distinguish between physical and chemical properties of substances.
2. Determine physical properties such as density, volume, mass, etc.
3. Make specific and accurate observations of materials and reactions as to color, odor, energy changes, gas evolution, precipitation, etc.
4. Identify evidence of chemical changes.

D. The student will be able to make precise measurements and evaluate experimental data through selected quantitative laboratory experiments.

1. Use a meter stick to measure length of any object in cm, mm, and meters.
2. Read centigrade thermometers and convert to Kelvin and Fahrenheit.
3. Read the volume contained in any graduated cylinder to within 0.5 ml.
4. Use a laboratory balance to determine the mass of any object to within 0.01 g.

E. The student will be able to make careful observations, report and interpret experimental results through selected qualitative laboratory experiments.

1. Interpret evidence of solubility and miscibility.
2. Collect a precipitate by filtration.
3. Predict the formation of precipitates based on principles of solubility.
4. Make accurate observations of state, color, and odor of elements, compounds, and mixtures.
5. Distinguish between elements, compounds, and mixtures.
6. Record evidence of chemical change occurring in a reaction.
7. Determine the relative activities of two metals in a single replacement reaction.
8. Arrange a group of metals from most active to least based upon observations of a series of single replacement reactions.

F. The student will be able to perform simple calculations from experimental data through selected quantitative laboratory experiments.

1. Calculate the densities of selected solids and water.
2. Calculate the percent of water in selected unknown hydrated salts.
3. Calculate the empirical formula for strontium iodide salt or other compound.
4. Determine the concentration of a basic solution when titrated with acid of a known concentration.
5. Determine the molar mass of an impurity due to freezing point depression.
6. Apply the rules of significant figures, rounding off, exponential notation, and instrument precision to the numerical results of measurements and calculations.
7. Measure volumes of liquids correctly with burettes, graduated cylinders and pipettes.
8. Apply titration techniques to the standardization of solutions.
9. Use pH paper, universal indicator, and special indicators in determinations of pH of solutions.
10. Use a spectrophotometer to measure percent transmission or absorbance of a

solution, and use the solutions of known concentration to prepare a standard curve.

VII. Evaluation and Assessment

The student will have demonstrated attainment of the general course objectives if he accumulates a minimum of 70 percent of the points possible.

Grades will be composed of tests, lab work, a comprehensive final exam, and may include other assignments. Lecture will count for 75 – 80% and the laboratory component will count for 20-25% of the student's grade. A minimum of three lecture exams and a comprehensive final exam will be given. In lab a minimum of one exam and a final exam will be given.

Grades will be given based upon the traditional scale:

A = 90 – 100%, B = 80 – 89%, C = 70 – 79%, D = 60 –69%, and F = below 60%.

VIII. Attendance

Students are expected to attend all classes for which they are registered. Students who are unable to attend class regularly, regardless of the reason or circumstance, should withdraw from that class before poor attendance interferes with the student's ability to achieve the objectives required in the course. Withdrawal from class can affect eligibility for federal financial aid.

IX. Statement on Discrimination/Harassment

The College and the Alabama State Board of Education are committed to providing both employment and educational environments free of harassment or discrimination related to an individual's race, color, gender, religion, national origin, age, or disability. Such harassment is a violation of State Board of Education policy. Any practice or behavior that constitutes harassment or discrimination will not be tolerated.

X. Americans with Disabilities

The Rehabilitation Act of 1973 (Section 504) and the Americans with Disabilities Act of 1990 state that qualified students with disabilities who meet the essential functions and academic requirements are entitled to reasonable accommodations. It is the student's responsibility to provide appropriate disability documentation to the College. The ADA Accommodations office is located in FSC 300 (205-856-7731).