

SPRINGFIELD TECHNICAL COMMUNITY COLLEGE

**ACADEMIC AFFAIRS**

Course Number: CHEM 203 Department: Chemistry

Course Title: General Chemistry 2 Semester: Spring Year: 1997

**Objectives/Competencies**

<b>Course Objective</b>	<b>Competencies</b>
<ol style="list-style-type: none"><li>1. Understand and apply valence bond theory.</li><li>2. Understand and apply theories and laws related to gases.</li><li>3. Understand and apply theories of intermolecular forces in liquids and solids.</li><li>4. Understand and apply theories and laws related to solutions.</li><li>5. Understand and apply the principles of kinetics.</li><li>6. Understand and apply the principles of chemical equilibrium.</li><li>7. Understand and apply the theories and principles of acids and bases.</li><li>8. Understand and apply the theories and principles of thermodynamics.</li></ol>	<ol style="list-style-type: none"><li>1. Explain the fundamental basis of valence bond theory; and explain why hybrid orbitals are often used to describe bonding in molecules rather than pure atomic orbitals.</li><li>2. Write hybridization schemes for the formation of sp, sp<sup>1</sup>, sp<sup>3</sup>, sp<sup>3</sup>d, and sp<sup>3</sup>d<sup>2</sup> hybrid orbitals; and predict the geometrical shapes of molecules in terms of the pure and hybrid orbitals used in bonding.</li><li>3. Use the relationship between VSEPR theory and valence bond theory to predict molecular geometries.</li><li>4. Describe multiple bonds between second period elements in terms of the overlap of sp, sp<sup>2</sup> and pure 2p orbitals to form σ bonds, and the sidewise overlap of p orbitals to form π bonds.</li><li>5. Propose plausible bonding schemes from Lewis structures or from experimental information about molecules (that is, bond lengths, bond angles, and so on).</li><li>6. Explain the fundamental basis of molecular orbital theory.</li><li>7. Know that two atomic orbitals combine to form a bonding</li></ol>

Course Objective	Competencies
	<p>and an antibonding molecular orbital and sketch these molecular orbitals.</p> <ol style="list-style-type: none"><li>8. Assign probable electron configurations, determine bond orders, and predict magnetic properties of the diatomic molecules and ions of the first and second period elements.</li><li>9. Describe the bonding in the benzene molecule (C<sub>6</sub>H<sub>6</sub>) through Lewis structures, valence bond theory, and molecular orbital theory.</li><li>10. Explain why a single valence structure is inadequate to explain the bonding in a resonance hybrid.</li><li>11. Be able to convert between the common units of pressure.</li><li>12. Explain the operation of a mercury barometer, an open-end manometer, and a closed-end manometer and be able to use the data obtained with these devices.</li><li>13. Learn Boyle's law both mathematically and graphically and be able to use it in calculations.</li><li>14. Learn Charles's law both mathematically and graphically and be able to use it in calculations.</li><li>15. Discuss the significance of the absolute zero of temperature and be able to convert between Celsius and Kelvin temperatures.</li><li>16. State what is meant by STP and the STP molar volume and be able to use the latter in calculations.</li><li>17. State and be able to use Avogadro's law.</li><li>18. Solve for one of P, V, n, or T when given values of the other three for an ideal gas.</li></ol>

Course Objective	Competencies
	<ol style="list-style-type: none"><li>19. Obtain the value of one final variable (P, V, n, or T), given the values of the other final variables and of all the initial variables, excluding those that remain unchanged, in the ideal gas law.</li><li>20. Use the alternate version of the ideal gas law for calculating molar masses of gases and determining gas densities.</li><li>21. Combine gas molar masses with empirical formulas to determine molecular formulas.</li><li>22. Solve stoichiometry problems involving gases.</li><li>23. Solve problems involving mixtures of gases with (a) the ideal gas law, (b) Dalton's law of partial pressures, or (c) Amagat's law of partial volumes.</li><li>24. Compute the pressure of gases collected over water.</li><li>25. Deduce the simple gas laws from the kinetic molecular theory.</li><li>26. Compute molecular velocities and know and apply Graham's law.</li><li>27. Explain surface tension and describe several phenomena based on it.</li><li>28. Describe vaporization, including its enthalpy using the latter in calculations.</li><li>29. Explain what occurs when a liquid vaporizes in a closed container, the dynamic equilibrium between a liquid and its vapor.</li><li>30. Determine vapor pressure experimentally, estimate values from tables or graphs, and predict whether vapor and/or</li></ol>

Course Objective	Competencies
	<p>liquid is present under specific conditions.</p> <ol style="list-style-type: none"><li>31. Explain how vapor pressure and temperature are related and the meaning of boiling. Also be able to use the Clausius-Clapeyron equation.</li><li>32. Describe the significance of the critical point.</li><li>33. Understand terms that apply to phase changes of solids.</li><li>34. Interpret simple phase diagrams and use phase diagrams to predict changes that occur as a substance is heated, cooled, or undergoes a change in pressure.</li><li>35. Describe the difference between intra- and intermolecular forces, distinguish the different types of forces between molecules, and explain how these forces influence molecular properties.</li><li>36. Describe aspects of network covalent bonding: the conditions that lead to it, the properties of solids in which it occurs, and some examples of these solids.</li><li>37. Predict relative lattice energies of ionic compounds and relate their magnitudes to the physical properties of those compounds (melting point, molar enthalpy of vaporization, and solubility in water).</li><li>38. Describe the three packing models for spheres and how x rays determine crystal structures.</li><li>39. Explain how the relative forces between molecules predict whether an ideal solution, a non ideal solution, or a heterogeneous mixture will form.</li><li>40. Know and be able to use percent concentration units: % (vol/vol), % (mass/mass), and % (mass/vol).</li></ol>

Course Objective	Competencies
	<ol style="list-style-type: none"><li>41. Know and be able to use the definitions of molarity and molality.</li><li>42. Know and be able to use the definitions of mole fraction and mole percent.</li><li>43. Distinguish among unsaturated, saturated, and supersaturated solutions and describe how a solute can be purified by recrystallization.</li><li>44. Apply Henry's law to calculations of gas solubility as a function of pressure.</li><li>45. Describe the properties of solutions that are colligative properties.</li><li>46. Apply Raoult's law. Describe the applications and the limitations of the law.</li><li>47. Explain how liquid-vapor equilibrium in non ideal solutions differs from that in ideal solutions.</li><li>48. Explain how vapor pressure lowering leads to boiling point elevation and also to freezing point depression. Use the equations for computing these.</li><li>49. Describe the process of osmosis and use van't Hoff's law of osmotic pressure.</li><li>50. Describe how the theory of electrolytic dissociation explains the behavior of aqueous solutions of strong, weak, and non electrolytes, including ionic concentrations and differences in the values of colligative properties from the value computed from equations.</li><li>51. Describe how interionic attractions in solution require modifications to Arrhenius's theory.</li></ol>

Course Objective	Competencies
	<ol style="list-style-type: none"><li>52. Describe how the rate of a reaction is related to the rate of disappearance of a reactant or formation of a product.</li><li>53. Explain how to obtain the data needed for a kinetic study from the results of a simple chemical analysis.</li><li>54. Establish the exact rate of a chemical reaction from the slope of a tangent line to the concentration vs. Time graph. Also, explain how to determine the initial rate.</li><li>55. State the meaning of reaction order and use the rate law to determine the order of a reaction.</li><li>56. Apply the method of initial rates to determine the rate law for a reaction.</li><li>57. Use the rate law and rate data to calculate a rate constant, <math>k</math>, or use the rate law and rate constant to calculate rate data.</li><li>58. Establish, through rate data, equations and graphs, whether a reaction is zero order, first order, or second order.</li><li>59. Determine the half life of a reaction that is zero order, first order, or second order.</li><li>60. Describe the collision theory of reactions, stating the factors that affect collision frequency and those that lead to favorable collisions.</li><li>61. Explain the concept of activation energy.</li><li>62. Explain how transition-state theory extends the theoretical explanation of chemical kinetics.</li><li>63. Use the Arrhenius equation in calculations involving rate constants, temperatures, and activation energies.</li></ol>

Course Objective	Competencies
	<ol style="list-style-type: none"><li>64. Describe the role of a catalyst and explain the difference between homogeneous and heterogeneous catalysis.</li><li>65. Describe a reaction mechanism, and distinguish between elementary processes and a net chemical reaction.</li><li>66. Derive the rate law from a simple mechanism with the concepts of steady-state conditions and rate-determining step.</li><li>67. Describe the condition of equilibrium in a reversible reaction.</li><li>68. Describe how equilibrium concentrations are established experimentally.</li><li>69. Write the equilibrium constant expression in terms of concentrations, <math>K_c</math>, for a reaction and use the value of <math>K_c</math> and the concentrations of all species but one to determine the equilibrium concentration of that species.</li><li>70. Derive <math>K</math> values for situations where chemical equations are reversed, multiplied through by constant coefficients, or added together.</li><li>71. Assess the relative importance of the forward and reverse reactions from the magnitude of an equilibrium constant.</li><li>72. Write an equilibrium constant expression in terms of partial pressures of gases, <math>K_p</math>; and relate a value of <math>K_p</math> to the corresponding value of <math>K_c</math>.</li><li>73. Know that the concentrations of pure liquids and solids are omitted from equilibrium constant expressions.</li><li>74. Calculate a numerical value of an equilibrium constant if equilibrium conditions are given.</li></ol>

Course Objective	Competencies
	<p>75. Predict the direction in which a reaction proceeds toward equilibrium by comparing the reaction quotient, <math>Q</math>, to <math>K_c</math>.</p> <p>76. Use the ideal gas law and Dalton's law of partial pressures in working with <math>K_p</math> expressions.</p> <p>77. Make qualitative predictions of how equilibrium conditions change when an equilibrium mixture is disturbed.</p> <p>78. Calculate the final equilibrium condition in a reversible reaction from a given set of initial conditions.</p> <p>79. Calculate the new equilibrium concentrations or partial pressures after an equilibrium system has adapted to changed conditions.</p> <p>80. Appreciate that the equilibrium constant for a reaction is related to the rate laws of the forward and reverse reactions but that one must have detailed knowledge of the mechanism to establish this relationship.</p> <p>81. Describe the similarities and differences among the Arrhenius, Bronsted-Lowry, and Lewis theories of acids and bases.</p> <p>82. Identify Bronsted-Lowry conjugate acids and bases and write equations of acid-base reactions.</p> <p>83. Identify Lewis acid-base reactions and write equations for acid-base reactions that involve them.</p> <p>84. Explain what self-ionization (or autoionization) is and describe the nature of the proton in aqueous solution.</p> <p>85. Calculate ionic concentrations in solutions of strong electrolytes, and relate <math>(H_3O^+)</math> and <math>(OH^-)</math> through <math>K_w</math>.</p>



Course Objective	Competencies
	<p>86. Given a value of any one of (<math>\text{H}_3\text{O}^+</math>), (<math>\text{OH}^-</math>), pH, and pOH, be able to compute values of the other three.</p> <p>87. Identify a weak acid or base, write a chemical equation to represent its ionization, and set up its ionization constant expression.</p> <p>88. Calculate one of <math>K_a</math>, (<math>\text{H}_3\text{O}^+</math>) or the molarity of a weak acid, given the other two (and perform similar calculations for a weak base). Know how to simplify these calculations by making suitable approximations.</p> <p>89. Describe the effect of common ions on the ionization of weak acids and bases, and calculate the concentrations of all species present in solutions of weak acids or bases and their common ions.</p> <p>90. Explain why the pH of water changes markedly when a small amount of <math>\text{H}_3\text{O}^+</math> or <math>\text{OH}^-</math> is added, and why the pH of a buffer does not change very much with a similar addition.</p> <p>91. Describe how buffer solutions can be prepared.</p> <p>92. Know the limitations of the basic equations used to determine the pH of buffer solutions (specifically the Henderson-Hasselbalch equation) by understanding their derivations.</p> <p>93. Calculate the pH of a buffer solution from concentrations of the buffer components and a value of <math>K_a</math> or <math>K_b</math>, and describe how to prepare a buffer that has a specific pH.</p> <p>94. Determine the changes in pH of buffer solutions that result from the addition of acids or bases.</p>

Course Objective	Competencies
	<p>95. Define and compute values for “buffer range” and “buffer capacity.”</p> <p>96. Explain how an acid-base indicator works to determine the equivalence point in a titration.</p> <p>97. Calculate pH values and plot the titration curve of a strong acid with a strong base.</p> <p>98. Define and compute values for equivalent weight, equivalent, and solution normality.</p> <p>99. Explain why a substance may have more than one equivalent weight and why one equivalent of acid always reacts with one equivalent of base.</p> <p>100. Apply the concepts of equivalent weight and normality to solve solution stoichiometry problems.</p> <p>101. State the first law of thermodynamics and the sign conventions used for heat, q, and work, w.</p> <p>102. Calculate the value of one of the following from known values of the other two: Energy, Heat, and Work..</p> <p>103. Explain the purpose served by the thermodynamic property of enthalpy (H), describe how H is related to E, and calculate one from the other for reactions involving gases.</p> <p>104. Explain the meaning of “spontaneous change” as it applies to chemical reactions.</p> <p>105. Explain why entropy is important and how it is related to the disorder of the system.</p> <p>106. Predict whether entropy increases or decreases for certain processes.</p>

Course Objective	Competencies
	<p>107. Explain why entropy alone is not used to predict a spontaneous change and why free energy is needed.</p> <p>108. Qualitatively predict whether reactions are spontaneous or non spontaneous.</p> <p>109. Determine <math>G_o</math> from tabulated data, both tables of <math>G_{fo}</math> and those of <math>H_{fo}</math> and <math>S</math>.</p> <p>110. Use the Gibbs-Helmholtz equation to determine <math>G_o</math> at various temperatures.</p> <p>111. Know that <math>G_{tr} = 0</math> at equilibrium. For phase change, use <math>S_{tr} - H_{tr}/T_{tr}</math> - the molar entropy of transition.</p> <p>112. Write thermodynamic equilibrium constant expressions <math>K_{eq}</math> for reactions and relate these to <math>K_p</math> and <math>K_c</math>.</p> <p>113. Compute values of <math>K_{eq}</math> from tabulated data and <math>G_o = -RT \ln K_{eq}</math>.</p> <p>114. Explain how absolute entropies of substances can be determined with the third law of thermodynamics.</p> <p>115. Relate the equilibrium constant to the standard molar enthalpy of reaction, <math>H_o</math>, and to Kelvin temperature, both graphically and algebraically.</p>

<b>Course Objective</b>	<b>Competencies</b>