AP Chemistry

AP Chemistry is a second-year course offering more extensive study in the following areas: the structure and states of matter, stoichiometry, kinetics and thermodynamics, nuclear chemistry, organic chemistry, oxidation-reduction reactions, and descriptive chemistry. This course will be lab and problem solving based. There will be a strong emphasis on laboratory procedure, analysis and presentation of results as part of the AP course validation.

Scientific Inquiry

The student will:

Comparison
1. use mathematics to express relationships between experimental variables. Scientific Inquiry 12.2
2. utilize units in computations performed by hand, calculator or computer.
3. perform appropriate mathematical operations to determine the theoretical result to an investigation. Scientific Inquiry 11.5
4. examine the similarities and differences between experimental and accepted values through several mathematical procedures (P12-4).

Organization
5. use common characteristics to group items.
6. exercise care for one’s self as lab experiments are completed. Scientific Inquiry 12.3
7. follow well defined procedures explained in the format of individual investigations.

Relationships
8. formulate individual investigations with specific hypotheses in mind. Scientific Inquiry 11.1
9. predict what might be wrong with an experimental design when observations vary widely.
10. construct alternate approaches to investigations and subsequently collect data. Scientific Inquiry 12.4
11. record observations, hypotheses, experiences and explanations in a laboratory journal. Scientific Inquiry 11.3
12. evaluate the validity of different approaches to investigations based upon the consistency of the data gathered. Scientific Inquiry 11.4
13. apply standard statistical tests to the collected data to determine
Inference

14. make, interpret, and discuss graphical representation of data. Scientific Inquiry 11.2

15. employ analogies to understand concepts in the course.

16. summarize investigations with an analysis of potential sources of error.

17. synthesize conclusions and make decisions based upon verifiable data.

18. develop multi-step logical thinking patterns.

Application

19. modify personal understandings of scientific principles based upon new information and experiences.

20. recognize the importance of sharing experimental findings with peers. Scientific Inquiry 11.3

21. select appropriate laboratory equipment to collect information, reporting the precision of the measurement as well.

22. recognize the impact of technological advancements on his/her life.

23. describe the role human thought has played in the historical development of chemical principles.

24. evaluate assumptions that have been used in reaching scientific conclusions. Scientific Inquiry 11.2

25. formulate testable hypotheses, develop and explain the appropriate procedures, controls and variables in scientific experimentation. Scientific Inquiry 12.1

Scientific Knowledge

The student will:

Structure of Matter

1. cite the historical evidence for the atomic theory. Scientific Ways of Knowing 12.3

A. Atomic Theory

2. study differences between the proton, electron and neutron.

3. discuss the chemical and physical methods for the determination of atomic masses of elements.

4. define the differences of atomic number, mass number, isotopic mass, actual mass, atomic mass, atomic weight and relative mass. Physical Sciences 11.1

5. calculate the average atomic mass of elements given the atomic mass,
and relative abundance of their natural isotopes.
6. identify the various kinds of quantum numbers and their designations.
7. apply the concept of quantum numbers in order to identify atomic orbitals and elements.
8. describe the modern view of atomic organization utilizing the concept of electron energy levels. Scientific Ways of Knowing 12.5
9. write the ground state electron configuration of elements. Physical Sciences 12.12
10. study the role of atomic spectra in the development and acceptance of the quantum mechanical view of the atom. Scientific Ways of Knowing 11.1 also Physical Sciences 12.13
11. explain the development of the Periodic Table from the work of Mendeleev to Moseley. Scientific Ways of Knowing 12.1
11.5 use historical examples to explain how new ideas are limited by the context in which they are conceived, are often initially rejected by the scientific community; sometimes spring from unexpected findings and usually grow slowly through contributions from many different investigators. Physical Sciences 12.14
12. list all families and series of elements on the Periodic Chart.
13. study periodic functions of atomic size, ionization energy, electron affinity and electro negativity in families of metals and non metals.
14. relate the number of valence electrons in families of elements to the oxidation states exhibited by these elements in nature.
15. establish ion stability relative to structure and energy content.

B. Chemical Bonding
16. classify chemical forces into the categories of ionic, covalent and metallic bonds. Physical Sciences 12.1
17. discuss the energetics of Ionic Bond formation by calculating Lattice Energy.
18. utilize the electronegativity scale to determine bond polarity.
19. list the factors involved in determining the size of monatomic cations and anions.
20. define the term isoelectronic series for ions.
21. write the electron configuration of monoatomic ions.
22. draw Lewis structures for compounds that adhere to the octet rule.
23. understand the concept of molecular resonance.
24. study compounds whose Lewis structure violate the octet rule.

25. relate the type of binding force found in the compound to its physical state and structure.

26. compare the stability of covalent molecules through calculation of bond energies.

27. identify the relationship between bond length and bond strength in covalent molecules.

28. explain the difference between sigma and pi bonds in molecular compounds.

29. list the steps involved in the hybridization of atomic orbitals in molecular compounds.

30. use the Valence-Shell Electron Pair Repulsion Model to explain molecular geometry of polyatomic ions and molecular compounds. Scientific Ways of Knowing 12.4

31. combine VSEPR theory and atomic hybridization to explain molecular geometry of multiple bonded covalent molecules.

32. study molecular orbital theory and apply it to covalent molecules. Scientific Ways of Knowing 12.2

33. list and explain the factors comprising the dipole moment of molecules.

33.5 investigate that nuclear fuel has advantages and disadvantages; therefore society must consider the trade-offs of it. Science and Technology 11.5

Nuclear Chemistry

34. list and explain the major types of radioactive decay.

35. consider nuclear stability as it relates to proton-neutron ratio, even-odd proton-neutron numbers, and proton-neutron forces.

36. describe the kinds of particles and energy emitted from the nucleus of a radioactive isotope. Physical Sciences 12.10

37. consider aspects of mass-defect and binding energy. Physical Sciences 12.7

38. complete nuclear half reactions.

39. calculate the half-life of a radioactive isotope. Physical Sciences 12.11

40. perform calculations based on the half-life of a radioactive isotope.
Physical Sciences 12.15

41. explain the difference between the processes of nuclear fission and fusion.

42. discuss several chemical applications of radioactivity technology. Science and Technology 11.2

43. discuss the ideal gas equation as a basis for the individual gas laws.

44. define molar volume of gases at STP and room conditions using the Avogadro Principle

45. apply Dalton’s law of partial pressures to a system in order to calculate individual gas pressures and mole fractions.

46. use the Kinetic-molecular theory as a basis for explaining the average kinetic energy and pressure of ideal gas molecules.

47. relate the average molecular kinetic energy to the absolute temperature of a gas.

48. define root-mean-square speed for gas molecules at specific temperatures.

49. discuss deviations from ideal conditions present in real gases.

50. apply the Kinetic-molecular theory in describing the properties of solids and liquids.

51. identify the different types of intermolecular forces in solids and liquids.

52. relate the strength of intermolecular forces to the magnitude of melting and boiling points in solids and liquids.

53. analyze the physical properties of compounds that exhibit hydrogen bonding.

54. study the energetics of phase changes.

55. create a heating curve for covalent compounds undergoing phase changes.

56. define critical pressure and critical temperature.

57. discuss various aspects of a phase diagram of a one-component system including critical pressure and temperature and triple point.

58. define dynamic equilibrium to explain vapor pressure equilibrium.
59. study the relationship between vapor pressure and boiling point for a liquid.

60. compare and contrast the stability of crystalline solids as a function of their intermolecular forces.

61. list types of solute particles in a true solution.

62. study the energetics of the solution process.

63. apply Hess’ Law to the solution process in order to calculate Heat of Solution.

64. discuss the factors of energy and disorder in determining the spontaneity of solution formation.

65. calculate the molality and molarity of a solution.

66. calculate the mole fraction of a component in a solution.

67. discuss the factors affecting solubility and rate of solution.

68. calculate solution concentration problems dealing with molarity and molality.

69. calculate molal F.P. depressions and BP elevations with molecular weights.

70. calculate problems dealing with Henry’s Law.

71. analyze the phase diagram of a solution in order to compare its freezing and boiling point to that of pure solvent.

72. calculate vapor pressure of solutions by applying Raoult’s law.

73. discuss conditions in real solutions which violate Raoult’s law.

74. determine the molecular weight of a solute by means of colligative properties.

75. calculate the osmotic pressure of solutions.

76. classify the four general types of chemical equations.

77. study the differences of the Arrhenius and Bronsted-Lowry Theory of Acids and Bases.

78. define amphoteric and relate it to acid/base character.

79. identify conjugate acid-base pairs.
80. calculate \([H_3O^+]\) and \([OH^-]\) given the pH scale and the ion-product constant for water, \(K_w\).

81. give experimental evidence for the difference between a strong and weak acid.

82. define the term poly protic acid.

83. write ionization equations and define \(K_a\) acid- dissociation constant.

84. write ionizations equations for weak bases and define \(K_b\) base-dissociation constant.

85. relate the acid base properties of a salt solution to the tendency of its cations and anions to react with water.

86. identify chemical species as Lewis Acids and Bases.

87. discuss the relationship between \(K_a\), \(K_b\) and \(K_w\).

88. complete and balance precipitation reactions.

89. use solubility rules to predict precipitates.

90. determine the oxidation number of all elements in chemical reactions.

91. write and balance oxidation/reduction reactions by the method of half-reactions in neutral, acidic and basic solutions.

92. compare and contrast the working of galvanic and electrolytic cells.

93. calculate the EMF of voltaic cells using the table of standard electrode potentials.

94. use standard electrode potentials to determine the spontaniety of oxidation-reduction reactions.

95. calculate the EMF of voltaic cells under non-standard conditions using the Nernst Equation.

96. study the relationship of EMF of a voltaic cell as a function of the concentrations of reactants and products.

97. describe the construction of electrolytic cells.

98. describe the quantitative aspects of Electrolysis through the application of Faradays’ Laws.
B. Stoichiometry

99. categorize chemical equations based on basic types of synthesis, decomposition, single replacement, double replacement and oxidation-reduction reactions.

100. calculate the percentage composition of a compound.

101. calculate the molar masses of compounds given the formula.

102. use Avogadro’s number to convert from grams to moles to number of particles.

103. determine the empirical formula of an unknown.

104. determine the molecular formula of a compound given its empirical formula.

105. write and balance formula equations.

106. solve stoichiometry mass-mass problems using limiting reactant-excess reactant method.

107. define molar volume of gases at STP and room conditions using the Avogadro Principle.

108. calculate stoichiometry mass-volume problems using molar volume of gases at STP and room conditions.

C. Equilibrium

109. define the term chemical equilibrium.

110. apply the Law of Mass Action to a system in equilibrium to calculate $K_c$ (equilibrium constant) for a gaseous system.

111. calculate the equilibrium constant, $K_p$, in terms of pressure for a gaseous system.

112. predict the reactant and product concentration at equilibrium given the magnitude of $K_c$.

113. compare the reaction quotient Q to the equilibrium construct $K_c$ to predict the direction of reaction.

114. use LeChateliers’ Principle to predict the shift of an equilibrium system in response to an external change. Physical Sciences 12.2

115. calculate the $[H_3O^+]$ of a weak acid given its $K_a$, acid-dissociation constant.

116. calculate pH for a solution of known concentration of a weak acid.
117. calculate pH for a solution from known concentration of weak base.

118. calculate the [OH−] of a weak base given its $K_b$, base-dissociation constant.

119. describe the common-ion effect for various equilibrium systems.

120. define the term buffer.

121. describe the composition and action of buffers.

122. calculate the pH of a buffer using the Henderson-Hasselbalch equation.

123. define the term solubility product constant $K_{sp}$.

124. calculate equilibrium concentration of ions in solution using $K_{sp}$.

125. use Q (ion-product) and $K_{sp}$ to determine the criteria for precipitation.

126. define the term reaction rate in terms of the change in concentration of a reactant per time interval.

127. determine the rate law of a chemical reaction given the starting concentrations and initial rate of reaction.

128. calculate the rate constant in the rate law of a chemical reaction.

129. study the rate laws for first and second order reactions overall.

130. apply the Collision Model to reaction systems in order to explain the relationship between temperature and rate of reaction.

131. use the Arrhenius equation to calculate activation energies of a chemical reaction.

132. use graphs to define activation energy.

133. classify different types of catalysts and apply them to reaction systems.

134. list the characteristics of elementary steps of a reaction mechanism.

135. investigate the relationship between the rate-determining step and the overall mechanism.

136. define the first law of thermodynamics in terms of energy conservation.

137. calculate changes in internal energy (of a system) in terms of the heat added to or liberated from the system plus the work done on or by the system.
system.

138. define state functions of a thermodynamic system.

E. Thermodynamics

139. define the term enthalpy.
140. calculate the enthalpy change of reaction systems.
141. construct an enthalpy diagram for a chemical reaction.
142. define Hess’ Law.
143. define standard enthalpy of formation of a compound.
144. calculate standard enthalpy change for a reaction by using standard enthalpies of formation and Hess’ Law.
145. define the term entropy and relate it to the spontaneity of a chemical reaction.
146. define the second law of thermodynamics in tems of entropy change.
147. calculate standard entropy changes for chemical systems.
148. calculate the standard free-energy change in a chemical process.
149. study the relationship between the free-energy change and the temperature of a chemical reaction not at standard conditions.
150. use the standard free-energy change to calculate the equilibrium constant for a particular chemical reaction.
151. explain how all matter tends toward more disorganized states and describe real world examples. Physical sciences 12.3
152. name and draw structural formulas for the alkane, alkene and alkyne hydrocarbon series.
153. survey the chemical properties and reactions of alkanes, alkenes and alkynes.
154. name and draw structural formulas for aromatic hydrocarbons.
155. define the functional groups for alcohols, ketones, ethers, aldehydes and carboxylic acids.
156. survey the chemical properties and reactions of all hydrocarbon derivatives. Physical Sciences 11.2
157. write equations for saponification and esterification.
Conditions for Learning Science

The student will:

1. perform experiments to collect data and verify chemical principles.
2. evaluate data by applying various methods of error analysis.
3. produce written reports of laboratory investigations.
4. maintain an organized record of observations collected during laboratory investigations.
5. compare/contrast the various levels of purity and toxicity of all reagents used in the laboratory portion of the course.
6. apply chemical principles to current environmental problems and concerns.
7. practice appropriate laboratory safety procedures.
8. utilize various means of technology to gather and interpret information relative to coursework.
9. engage in multi-faceted problem solving activities.
10. operate sophisticated chemical instrumentation.
11. Explain how theories are judged by how well they fit with other theories, the range of included observations, how well they explain observations and how effective they are in predicting new findings. Scientific Ways of Knowing 11.7
12. research how scientific inquiry is driven by the desire to understand the natural world and how technological design is driven by the need to meet human needs and solve human problems. Science and Technology 12.3
13. explain why basic concepts and principles of science and technology should be a part of active debate about the economics, policies, politics and ethics of various science-related and technology-related challenges. Science and Technology 11.4

Applications for Science Learning

The student will:

Course of Study

AP Chemistry

Initiated 2003-2004

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1. consider science as a realistic personal career. Scientific Ways of Knowing 11.11
2. differentiate between observations and inferences.
3. recognize the many aspects of science in individual lifestyles (P12-5)
4. utilize various methods of technology to present experimental results (P12-4)
5. present to the class experimental findings for discussion and explanation.
6. investigate the relationship between chemical principles and social issues.
7. apply scientific inquiry to evaluate results of scientific investigations, observations, theoretical models and the explanations proposed by other scientists. Scientific Ways of Knowing 11.2
8. explain how science often advances the introduction of new technologies and how solving technological problems often results in new scientific knowledge. Science and Technology 12.1
9. describe how technologies often extend the current levels of scientific understanding and introduce new areas of research. Science and Technology 12.2
10. identify that science and technology are essential social enterprises but alone they can only indicate what can happen, not what should happen. Realize the latter involves human decisions about the use of knowledge. Science and Technology 11.1
11. research sources of energy beyond traditional fuels and the advantages, disadvantages and trade-offs society must consider when using alternative sources. Science and Technology 11.6