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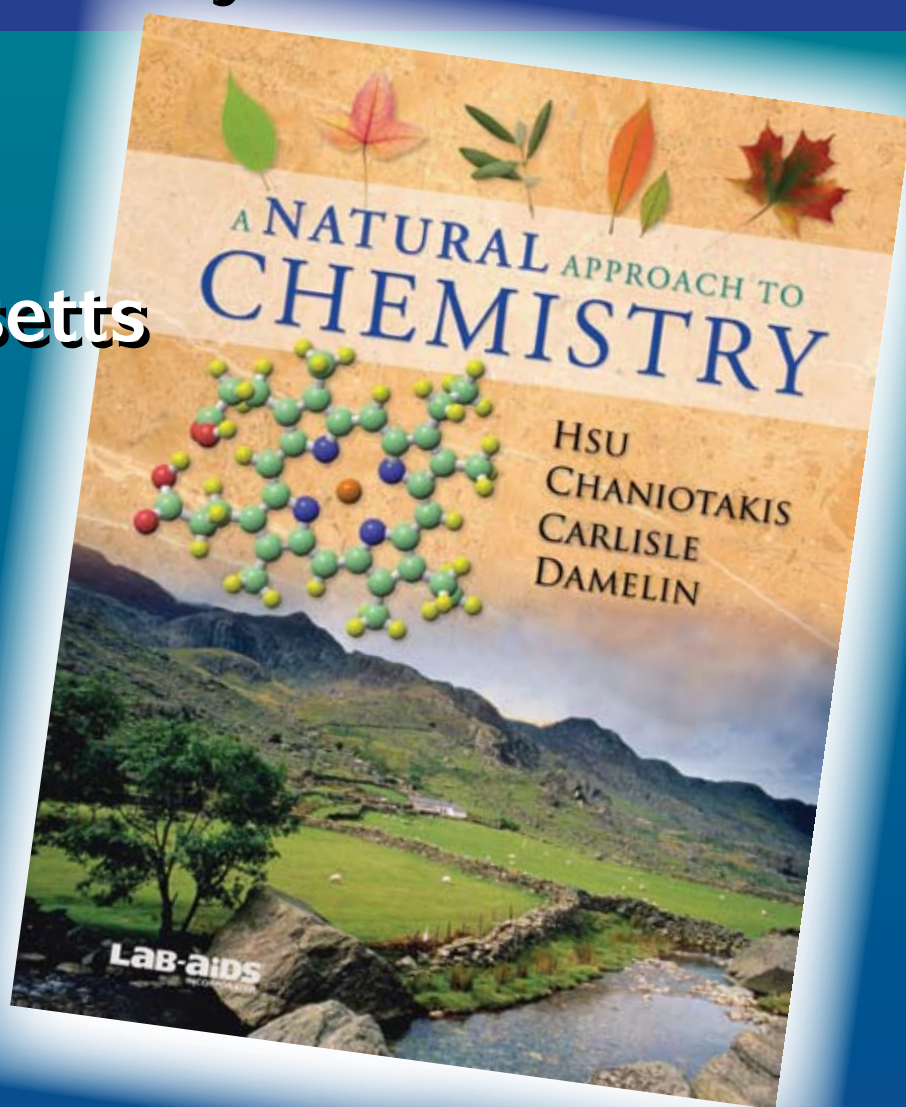
INSTITUTE



# A Natural Approach to Chemistry

LA179/09

**Correlation  
to the  
Massachusetts  
Learning  
Standards**



**Full First-Year  
Course of High School Chemistry**

The logo for LAB-AIDS INCORPORATED, featuring the text "LAB-aids" in a bold, sans-serif font with a registered trademark symbol, and "INCORPORATED" in a smaller font below it.The text "EXPERIENCING SCIENCE™" in a blue, sans-serif font, positioned to the right of the LAB-AIDS logo.

***A Natural Approach to Chemistry Correlation  
to the  
Massachusetts Learning Standards***

A Natural Approach to Chemistry (NAC) is a complete learning system consisting of a textbook, full color lab manual, and equipment package including the LAB-MASTER, a state-of-the art digital lab partner. The program takes a fresh look at how chemistry is used today, both in and out of the laboratory. Experiments have been developed that allow students to do real, quantitative chemistry using only non-toxic chemicals that are easily disposed of. Examples throughout the course emphasize the importance of chemistry in the human body, the laboratory, and the environment. Traditional chemistry classrooms are not required to teach this course. The program uses the 5-E model, builds on a foundation of physics, has reading and math levels appropriate for use in grades 10-12 and satisfies high school content standards for chemistry. A Natural Approach to Chemistry was written by Dr. Tom Hsu, Dr. Manos Chaniotakis, Debbie Carlisle, and Dan Damelin of Ergopedia, Inc., in Cambridge MA, and published and distributed nationally by LAB-AIDS, Inc.

This correlation was prepared by Ergopedia and is intended to show selected locations in NAC programs that support the MA Chemistry Learning Standards. It is not an exhaustive list; other locations may exist that are not listed here. For example, the student lab manual, with more than 60 labs, is currently in press, and the support for the MA chemistry learning standards provided in the lab manual has not been listed here; it will be provided in future updates of the document. Even so, it should be apparent that the NAC program is 100% conforming to the MA Chemistry Learning Standards. For more information about this correlation or for questions about review copies, presentations, or any matters related to sales or service, please contact Ruth Ann McDougall, LAB-AIDS Massachusetts Regional Manager at 978-475-3742, or voicemail: 800-381-8003, ext. 137, or by e-mail at [rmcdougall@lab-aids.com](mailto:rmcdougall@lab-aids.com), or visit us on the web at [www.lab-aids.com](http://www.lab-aids.com).

## A Natural Approach to Chemistry to the Massachusetts Learning Standards

Science Inquiry Standard	Student Text Page	Detail	Lab Investigation Manual Page	Detail
<b>SIS1: Make observations, raise questions and formulate hypothesis.</b>  A. Observe the world from a scientific perspective	43	Observations leading to the periodic table		
	103	Observing chemical reactions		
	167	Observing the properties of elements		
	473	Observing electrochemical behavior		
	605	Observing the water cycle		
<b>SIS1: Make observations, raise questions and formulate hypothesis.</b>  B. Pose questions and form hypothesis based on personal observations, scientific articles, experiments and knowledge	20	Develop the process of experimentation and hypothesis		
	24	Conclusion and hypothesis		
	295	Observing chemical reactions and develop hypothesis of how they happen		
	604	Scientific research and green chemistry		
<b>SIS1: Make observations, raise questions and formulate hypothesis.</b>  C. Read, interpret, and examine the credibility and validity of scientific claims in different sources of information, such as scientific articles, advertisements, or media stories.			20A 17B 15B	

## A Natural Approach to Chemistry to the Massachusetts Learning Standards

Science Inquiry Standard	Student Text Page	Detail	Lab Investigation Manual Page	Detail
<b>SIS2: Design and conduct scientific investigations.</b>  A. Articulate and explain the major concepts being investigated and the purpose of an investigation.	19	Inquiry and scientific investigation	3A 3B	
	24	Investigation and data collection	2A 2B	
	26	The scientific method. How do we put it all together	4A 4B 6A 6B	
	120	Systems and the process for investigating them	11A 11C	
	280	Developing the investigation process: The example of coffee cup calorimetry	13C 14A 14C 15A 15B 15C	
<b>SIS2: Design and conduct scientific investigations.</b>  B. Select required materials, equipment, and conditions for conducting an experiment.			3A 3B 2A 2B 4A 4B 6A 6B 11A 11C 13C 14A 14C 15A 15B 15C	
<b>SIS2: Design and conduct scientific investigations.</b>  C. Identify independent and dependent variables.	21	Control variables	3B 3A	Specific heat  Heat and temperature  Math review

## A Natural Approach to Chemistry to the Massachusetts Learning Standards

Science Inquiry Standard	Student Text Page	Detail	Lab Investigation Manual Page	Detail
<b>SIS2: Design and conduct scientific investigations.</b>  D. Write procedures that are clear and replicable.			2A 2B 3A 2C 3B 3C 4C 5B 9A, 9B 9C 17C 20B	The art for writing an effective lab report
<b>SIS2: Design and conduct scientific investigations.</b>  E. Employ appropriate methods for accurately and consistently <ol style="list-style-type: none"> <li>1. making observations</li> <li>2. making and recording measurements at appropriate levels of precision</li> <li>3. collecting data or evidence in an organized way</li> </ol>	14  15	Accuracy and precision  Precision and significant figures	3A 3B 2A 2B 2C 4A 4B 6A 6B 11A 11B 11C 13C 13D 14A 14C 15A 15B 15C 20A 20B	
<b>SIS2: Design and conduct scientific investigations.</b>  F. Properly use instruments, equipment, and materials (e.g., scales, probeware, meter sticks, microscopes, computers) including set-up, calibration (if required), technique, maintenance, and storage.			5B 5C	Using the Lab-Master  Lab safety quiz What's in the Lab
<b>SIS2: Design and conduct scientific investigations.</b>  G. Follow safety guidelines.				Lab Safety guidelines and procedures  Lab safety quiz

## A Natural Approach to Chemistry to the Massachusetts Learning Standards

Science Inquiry Standard	Student Text Page	Detail	Lab Investigation Manual Page	Detail
<p><b>SIS3. Analyze and interpret results of scientific investigations.</b></p> <p>A. Present relationships between and among variables in appropriate forms.</p> <ol style="list-style-type: none"> <li>1. Represent data and relationships between and among variables in charts and graphs.</li> <li>2. Use appropriate technology (e.g., graphing software) and other tools.</li> </ol>			3A 3B 2A 2B 2C 4A 4B 6A 6B 11A 13B 13C 14C 15A 15B	<p>This inquiry standard is explored in every laboratory investigation</p> <p>Using the Lab-Master</p>
<p><b>SIS3. Analyze and interpret results of scientific investigations.</b></p> <p>B. Use mathematical operations to analyze and interpret data results.</p>	22  23  24  30  35  164  341	Calculate uncertainty of data  Comparing data  Drawing conclusions from data  Measurement and analysis  Problems that require data analysis and interpretation  Exercises and problems that explore scientific theories  Calculating percent yield. A step by step presentation	3B 2A 2B 2C 4A 4B 6A 6B 9A 9B 11A 13B 13C 14C 15A 15B	Math review

## A Natural Approach to Chemistry to the Massachusetts Learning Standards

Science Inquiry Standard	Student Text Page	Detail	Lab Investigation Manual Page	Detail
<b>SIS3. Analyze and interpret results of scientific investigations.</b>  C. Assess the reliability of data and identify reasons for inconsistent results, such as sources of error or uncontrolled conditions.	22	Sources of error and presentation of error in data	1A 1B 2A	This inquiry standard is explored in every laboratory investigation  Using the Lab-Master
	23	Error and reproducibility	2B 2C	
	24	Exploring the meaning of error in various problems	3A 3B 4A 4B	
<b>SIS3. Analyze and interpret results of scientific investigations.</b>  D. Use results of an experiment to develop a conclusion to an investigation that addresses the initial questions and supports or refutes the stated hypothesis.	295	Investigating the reaction of iron rusting	15A 15B 15C 2A 2B 2C 3A 4A 4B 9A 9D 13C 13D 14A 14C	
<b>SIS3. Analyze and interpret results of scientific investigations.</b>  E. State questions raised by an experiment that may require further investigation.			3A 3B 2A 2B 2C 4A 4B 6A 6B 11A 11B 11C 13C 13D 14A 14C 15A 15B 15C 20A 20B	

## A Natural Approach to Chemistry to the Massachusetts Learning Standards

Science Inquiry Standard	Student Text Page	Detail	Lab Investigation Manual Page	Detail
<p><b>SIS4: Communicate and apply the results of scientific investigations.</b></p> <p>A. Develop descriptions of and explanations for scientific concepts that were a focus of one or more investigations.</p>			<p>9A 9B 15A 15B 15C</p>	Writing an effective lab report
<p><b>SIS4: Communicate and apply the results of scientific investigations.</b></p> <p>B. Review information, explain statistical analysis, and summarize data collected and analyzed as the result of an investigation.</p>	<p>22</p> <p>24</p>	<p>Statistical analysis. Uncertainty and error</p> <p>Estimating the error of a data set Data error and conclusions</p>	<p>3B 2C 4A 4B 6A 6B 11A 11B 11C 13C 13D 14A 14C 15C 20B</p>	
<p><b>SIS4: Communicate and apply the results of scientific investigations.</b></p> <p>C. Explain diagrams and charts that represent relationships of variables.</p>	<p>25</p> <p>74</p> <p>105</p> <p>171</p>	<p>Graph as a scientific tool</p> <p>Explaining temperature with a graph</p> <p>Graphical representation of physical and chemical change</p> <p>Explaining the periodic table with a graph</p>		Graphs explained Single and multivariable graphs

## A Natural Approach to Chemistry to the Massachusetts Learning Standards

Science Inquiry Standard	Student Text Page	Detail	Lab Investigation Manual Page	Detail
<p><b>SIS4: Communicate and apply the results of scientific investigations.</b></p> <p>D. Construct a reasoned argument and respond appropriately to critical comments and questions.</p>			3B 2C 4A 4B 6A 6B 11A 11B 11C 13C 13D 14A 14C 15C 20B	Effective communication. The art for writing an effective lab report
<p><b>SIS4: Communicate and apply the results of scientific investigations.</b></p> <p>E. Use language and vocabulary appropriately, speak clearly and logically, and use appropriate technology (e.g., presentation software) and other tools to present findings.</p>			3A 3B 2A 2B 2C 4A 4B 6A 6B 11A 11B 11C 13C 13D 14A 14C 15A 15B 15C 20A 20B	All of these labs have a presentation component.  Use the Lab-Master to collect data and then interface with a computer to analyze data using any preferable graphing and presentation software.
<p><b>SIS4: Communicate and apply the results of scientific investigations.</b></p> <p>F. Use and refine scientific models that simulate physical processes or phenomena.</p>			20A 20B 15B 15C 13B 13C	Compare the data from these experiments to various nuclear, electrochemical, acid base and gas scientific models.

## A Natural Approach to Chemistry to the Massachusetts Learning Standards

Content Standard	Student text page	Detail
<b>Chem 1.1 Physical Sciences (Chemistry)</b>  High School  Properties of Matter  Identify and explain physical properties (e.g., density, melting point, boiling point, conductivity, malleability) and chemical properties (e.g., the ability to form new substances).	10	Density defined
	39	Density is a physical property of matter
	88	Melting point defined
	89	Boiling point defined
	171	Density of elements vs their atomic mass and the periodic table.
	229	Malleability represents different types of attractive forces and bonding patterns
	284	Density vs Concentration
	512	Electrical and thermal conductivity explained
513	Density of solids	
<b>Chem 1.1 Physical Sciences (Chemistry)</b>  High School  Properties of Matter  Distinguish between chemical and physical changes.	39	Physical changes explained
	40	Chemical changes explained
	102	Differences between chemical and physical changes
	379	Physical equilibrium involves physical changes
	605	Example of physical change
	619	Example of chemical and physical changes

## A Natural Approach to Chemistry to the Massachusetts Learning Standards

Content Standard	Student text page	Detail
<b>Chem 1.2 Physical Sciences (Chemistry)</b>  High School  Properties of Matter  Explain the difference between pure substances (elements and compounds) and mixtures.	38	Explain the differences between substances and mixtures
	47	Differences between compounds and mixtures
	52	Ionic compounds explained
	56	Types of mixtures
	64	Properties of compounds
	107	Matter as compounds
	121	Compounds and activation energy
<b>Chem 1.2 Physical Sciences (Chemistry)</b>  High School  Properties of Matter  Differentiate between heterogeneous and homogeneous mixtures.	37	Mixtures defined
	47	Compounds vs mixtures
	56	Homogeneous and Heterogeneous mixtures defined
	62	Mixtures of gasses
	81	Mixtures and the first law of thermodynamics
	260	Examples of homogeneous mixtures
	507	Example of heterogeneous catalysts
<b>Chem 1.3 Physical Sciences (Chemistry)</b>  High School  Properties of Matter  Describe the three normal states of matter (solid, liquid, gas) in terms of energy, particle motion, and phase transitions.	27	Different phases of matter identified
	37	Classifying states of matter
	39	Phases are physical property
	71	Distinguishing between liquids and gasses
	73	Different characteristics of the states of matter
	87	Conductivity of the different states of matter
	104	Chemical changes of the different states of matter

## A Natural Approach to Chemistry to the Massachusetts Learning Standards

Content Standard	Student text page	Detail
<p><b>Chem 2.1 Physical Sciences (Chemistry)</b></p> <p>High School</p> <p>Atomic Structure and Nuclear Chemistry</p> <p>Recognize discoveries from Dalton (atomic theory), Thomson (the electron), Rutherford (the nucleus), and Bohr (planetary model of atom), and understand how each discovery leads to modern theory.</p>	<p>135</p> <p>137</p> <p>140</p> <p>144</p> <p>198</p>	<p>Atomic theories explained</p> <p>Components of the atom identified</p> <p>Electron cloud represented</p> <p>Quantum theory explained</p> <p>Electron cloud and polarization</p>
<p><b>Chem 2.2 Physical Sciences (Chemistry)</b></p> <p>High School</p> <p>Atomic Structure and Nuclear Chemistry</p> <p>Describe Rutherford's "gold foil" experiment that led to the discovery of the nuclear atom. Identify the major components (protons, neutrons, and electrons) of the nuclear atom and explain how they interact.</p>	<p>136</p> <p>137</p> <p>140</p> <p>143</p> <p>147</p>	<p>Gold foil experiment represented</p> <p>Composition of an atom (Protons, neutrons, and electrons) explained</p> <p>Properties of electrons in an atom</p> <p>Charge of an atom</p> <p>Electron behavior described</p>
<p><b>Chem 2.3 Physical Sciences (Chemistry)</b></p> <p>High School</p> <p>Atomic Structure and Nuclear Chemistry</p> <p>Interpret and apply the laws of conservation of mass, constant composition (definite proportions), and multiple proportions.</p>	<p>117</p> <p>298</p> <p>616</p>	<p>Example of the law of conservation of mass</p> <p>Law of conservation of mass defined</p> <p>Constant composition of ocean water</p>

## A Natural Approach to Chemistry to the Massachusetts Learning Standards

Content Standard	Student text page	Detail
<p><b>Chem 2.4 Physical Sciences (Chemistry)</b></p> <p>High School</p> <p>Atomic Structure and Nuclear Chemistry</p> <p>Write the electron configurations for the first twenty elements of the periodic table.</p>	<p>152</p> <p>180</p>	<p>Electron configurations explained</p> <p>Electron configurations of carbon, nitrogen, and oxygen</p>
<p><b>Chem 2.5 Physical Sciences (Chemistry)</b></p> <p>High School</p> <p>Atomic Structure and Nuclear Chemistry</p> <p>Identify the three main types of radioactive decay (alpha, beta, and gamma) and compare their properties (composition, mass, charge, and penetrating power).</p>	<p>637</p> <p>639</p> <p>640</p> <p>641</p>	<p>Different types of radioactive decay explained.</p> <p>Alpha decay explained</p> <p>Beta decay explained</p> <p>Gamma decay explained</p>
<p><b>Chem 2.6 Physical Sciences (Chemistry)</b></p> <p>High School</p> <p>Atomic Structure and Nuclear Chemistry</p> <p>Describe the process of radioactive decay by using nuclear equations, and explain the concept of half-life for an isotope (for example, C-14 is a powerful tool in determining the age of objects).</p>	<p>644</p> <p>641</p> <p>643</p> <p>645</p>	<p>Half life explained</p> <p>Identifying different types of decay</p> <p>Mathematical equations for radioactive decay</p> <p>Carbon dating explained</p>

## A Natural Approach to Chemistry to the Massachusetts Learning Standards

Content Standard	Student text page	Detail
<b>Chem 2.7 Physical Sciences (Chemistry)</b> High School Atomic Structure and Nuclear Chemistry Compare and contrast nuclear fission and nuclear fusion.	89 647 652 654	Examples of fusion Examples of fission Fission reactions and products explained Fusion reactions and energy explained
<b>Chem 3.1 Physical Sciences (Chemistry)</b> High School Periodicity Explain the relationship of an element's position on the periodic table to its atomic number.	44 107 108 138 143	The periodic table and the relationship to element atomic numbers explained Finding the atomic number on the periodic table Definition of atomic number Explanation and examples of atomic numbers Atomic number and charges
<b>Chem 3.1 Physical Sciences (Chemistry)</b> High School Periodicity Identify families (groups) and periods on the periodic table.	175 177 178 179 180 181 182	Element groups represented Properties of alkali metals Alkaline earth metals represented Properties of transition metals Properties of carbon, oxygen and nitrogen specifically Properties of the Halogen family Properties of the Noble gasses

## A Natural Approach to Chemistry to the Massachusetts Learning Standards

Content Standard	Student text page	Detail
<b>Chem 3.2 Physical Sciences (Chemistry)</b>  High School  Periodicity  Use the periodic table to identify the three classes of elements: metals, nonmetals, and metalloids.	43	Different classes shown on the periodic table
	134	Elements shown and organized into classes
	168	Three classes of elements identified
	175	Examples of the different classes
	202	Non-metals and covalent bonds
	212	Non-metals and hydrogen properties
<b>Chem 3.3 Physical Sciences (Chemistry)</b>  High School  Periodicity  Relate the position of an element on the periodic table to its electron configuration and compare its reactivity to the reactivity of other elements in the table.	112	Reactivity of elements based on their position in the periodic table
	152	Electron configurations in relation to the periodic table
	153	Electron configuration examples
	154	Periodic table organized based on orbitals and atomic structure
	180	Electron configurations of carbon, nitrogen and oxygen
<b>Chem 3.4 Physical Sciences (Chemistry)</b>  High School  Periodicity  Identify trends on the periodic table (ionization energy, electronegativity, and relative sizes of atoms and ions).	172	Examples of atomic radius of different elements
	173	Ionization energy, electronegativity, atomic radius defined
	173	Trends on periodic table represented
	176	Relationship between atomic radius and orbitals explained
	201	Periodic properties and bond types

## A Natural Approach to Chemistry to the Massachusetts Learning Standards

Content Standard	Student text page	Detail
<b>Chem 4.1 Physical Sciences (Chemistry)</b> High School Chemical Bonding Explain how atoms combine to form compounds through both ionic and covalent bonding.	109	Covalent bonds explained
	111	Ionic bonds explained
	113	Different types of compounds
	115	Compounds in chemical equations
	123	Examples of ionic compounds
	143	Ionic compounds at the atomic level
<b>Chem 4.1 Physical Sciences (Chemistry)</b> High School Chemical Bonding Predict chemical formulas based on the number of valence electrons.	184	Valence electrons explained
	185	Determining valence electrons
	187	Valence electrons and Lewis dot notation
	207	Valence electrons and bonding
	208	Octet rule explained
	217	Valence shell electron pair repulsion explained
<b>Chem 4.2 Physical Sciences (Chemistry)</b> High School Chemical Bonding Draw Lewis dot structures for simple molecules and ionic compounds.	187	Lewis dot structures explained
	188	Simple Lewis dot structures depicted
	213	Lewis dot structure and bonding
	214	Example of a Lewis dot structure
	216	Lewis dot structures for molecules with double and/or triple bonds

## A Natural Approach to Chemistry to the Massachusetts Learning Standards

Content Standard	Student text page	Detail
<b>Chem 4.3 Physical Sciences (Chemistry)</b>  High School  Chemical Bonding  Use electronegativity to explain the difference between polar and nonpolar covalent bonds.	201	Predicting bond type
	202	Covalent bonds defined
	203	Ionic and metallic bonds defined
	204	Explanation of how the difference in electronegativity determines bond type
	479	Polar covalent bonds described
	530	Polar hydrogen bonds depicted
<b>Chem 4.4 Physical Sciences (Chemistry)</b>  High School  Chemical Bonding  Use valence-shell electron-pair repulsion theory (VSEPR) to predict the molecular geometry (linear, trigonal planar, and tetrahedral) of simple molecules.	217	VSEPR explained
	217	Relationship between molecular geometry and VSEPR explained
	218	Linear shapes explained
	219	Trigonal planar shapes explained
	221	Tetrahedral shapes explained
<b>Chem 4.5 Physical Sciences (Chemistry)</b>  High School  Chemical Bonding  Identify how hydrogen bonding in water affects a variety of physical, chemical, and biological phenomena (e.g., surface tension, capillary action, density, boiling point).	247	Hydrogen bonding in water explained
	247	Surface tension defined
	248	Examples of hydrogen bonding
	248	Protein structures with hydrogen bonds
	529	Capillary action defined

## A Natural Approach to Chemistry to the Massachusetts Learning Standards

Content Standard	Student text page	Detail
<p><b>Chem 4.6 Physical Sciences (Chemistry)</b></p> <p>High School</p> <p>Chemical Bonding</p> <p>Name and write the chemical formulas for simple ionic and molecular compounds, including those that contain the polyatomic ions: ammonium, carbonate, hydroxide, nitrate, phosphate, and sulfate.</p>	<p>232</p> <p>232</p> <p>233</p> <p>234</p> <p>235</p>	<p>Polyatomic ions defined</p> <p>Ammonium chemical formula</p> <p>Formulas for ionic compounds depicted</p> <p>Ionic formula writing with polyatomic ions</p> <p>Naming binary ionic compounds</p>
<p><b>Chem 5.1 Physical Sciences (Chemistry)</b></p> <p>High School</p> <p>Chemical Reactions and Stoichiometry</p> <p>Balance chemical equations by applying the laws of conservation of mass and constant composition (definite proportions).</p>	<p>115</p> <p>116</p> <p>117</p> <p>298</p>	<p>Balancing chemical equations explained</p> <p>Examples of balancing chemical equations</p> <p>Example of the law of conservation of mass</p> <p>Law of conservation of mass defined</p>
<p><b>Chem 5.2 Physical Sciences (Chemistry)</b></p> <p>High School</p> <p>Chemical Reactions and Stoichiometry</p> <p>Classify chemical reactions as synthesis (combination), decomposition, single displacement (replacement), double displacement, and combustion.</p>	<p>305</p> <p>306</p> <p>306</p> <p>307</p> <p>329</p>	<p>Synthesis reaction explained</p> <p>Decomposition reaction explained</p> <p>Single displacement reaction explained</p> <p>Double replacement reaction explained</p> <p>Example of combustion</p>

## A Natural Approach to Chemistry to the Massachusetts Learning Standards

Content Standard	Student text page	Detail
<b>Chem 5.3 Physical Sciences (Chemistry)</b> High School Chemical Reactions and Stoichiometry Use the mole concept to determine number of particles and molar mass for elements and compounds.	54 250 328 329 330	Example of calculations with molar mass Calculating molar mass Calculating molar mass Example of moles to molecules Mole to mole relationships
<b>Chem 5.4 Physical Sciences (Chemistry)</b> High School Chemical Reactions and Stoichiometry Determine percent compositions, empirical formulas, and molecular formulas.	251 252 252 253 253	Percent composition explained Calculating empirical formula Examples of empirical formula Calculating molecular formula Examples of molecular formula
<b>Chem 5.6 Physical Sciences (Chemistry)</b> High School Chemical Reactions and Stoichiometry Calculate the mass-to-mass stoichiometry for a chemical reaction.	339 340 341 342	Percent yield defined Explanation of how reaction yields are not always 100% Example of percent yield calculation Calculating percent yield in a chemical reaction
<b>Chem 6.1 Physical Sciences (Chemistry)</b> High School States of Matter, Kinetic Molecular Theory, and Thermochemistry Using the kinetic molecular theory, explain the behavior of gases and the relationship between pressure and volume (Boyle's law), volume and temperature (Charles's law), pressure and temperature (Gay-Lussac's law), and the number of particles in a gas sample (Avogadro's hypothesis).	451 452 454 455 457	Boyle's law explained Applications of Boyle's law Volume vs Temperature Charles' law explained Avogadro's law explained

## A Natural Approach to Chemistry to the Massachusetts Learning Standards

Content Standard	Student text page	Detail
<b>Chem 6.1 Physical Sciences (Chemistry)</b> High School States of Matter, Kinetic Molecular Theory, and Thermochemistry Use the combined gas law to determine changes in pressure, volume, and temperature.	456	Combined gas law explained
	456	Combined gas law derived from Charles' and Boyle's laws
	457	Effects of temperature on pressure
	458	Volumes of the different states of matter at different temperatures represented
<b>Chem 6.2 Physical Sciences (Chemistry)</b> High School States of Matter, Kinetic Molecular Theory, and Thermochemistry Perform calculations using the ideal gas law.	459	Ideal gas law defined
	460	Conditions of the ideal gas law
	460	Differences between real and ideal gasses explained
	461	Using the ideal gas law under changing conditions
<b>Chem 6.2 Physical Sciences (Chemistry)</b> High School States of Matter, Kinetic Molecular Theory, and Thermochemistry Understand the molar volume at 273 K and 1 atmosphere (STP).	461	Ideal gas law equation explained
	62	Molar volume defined
	62	Standard temperature and pressure explained
	62	Molar volume at 273 K and STP depicted
460	Molar volume explained	
460	One mole of any gas at STP and 273 K will occupy 22.4 L	

## A Natural Approach to Chemistry to the Massachusetts Learning Standards

Content Standard	Student text page	Detail
<p><b>Chem 6.3 Physical Sciences (Chemistry)</b></p> <p>High School</p> <p>States of Matter, Kinetic Molecular Theory, and Thermochemistry</p> <p>Using the kinetic molecular theory, describe and contrast the properties of gases, liquids, and solids. Explain, at the molecular level, the behavior of matter as it undergoes phase transitions.</p>	<p>444</p> <p>27</p> <p>37</p> <p>71</p> <p>73</p> <p>87</p> <p>104</p>	<p>Kinetic molecular theory explained</p> <p>Different phases of matter identified</p> <p>Classifying states of matter</p> <p>Distinguishing between liquids and gasses</p> <p>Different characteristics of the states of matter</p> <p>Conductivity of the different states of matter</p> <p>Chemical changes of the different states of matter</p>
<p><b>Chem 6.4 Physical Sciences (Chemistry)</b></p> <p>High School</p> <p>States of Matter, Kinetic Molecular Theory, and Thermochemistry</p> <p>Describe the law of conservation of energy.</p>	<p>28</p> <p>28</p> <p>29</p> <p>29</p> <p>29</p>	<p>Law of conservation of energy explained</p> <p>Examples of different ways people harvest energy</p> <p>Examples of the conservation of energy</p> <p>Explanation of how energy cannot be created</p> <p>Different forms of energy shown</p>
<p><b>Chem 6.4 Physical Sciences (Chemistry)</b></p> <p>High School</p> <p>States of Matter, Kinetic Molecular Theory, and Thermochemistry</p> <p>Explain the difference between an endothermic process and an exothermic process.</p>	<p>118</p> <p>119</p> <p>121</p> <p>121</p>	<p>Endothermic reactions explained</p> <p>Exothermic reactions explained</p> <p>Exothermic reactions do not occur spontaneously</p> <p>Exothermic reactions require activation energy</p>

## A Natural Approach to Chemistry to the Massachusetts Learning Standards

Content Standard	Student text page	Detail
<b>Chem 6.5 Physical Sciences (Chemistry)</b> High School States of Matter, Kinetic Molecular Theory, and Thermochemistry Recognize that there is a natural tendency for systems to move in a direction of disorder or randomness (entropy).	285	Entropy defined
	285	Entropy differences for the different states of matter
	285	Randomness in different states
	285	Why entropy occurs
	285	More variety in particles increases the disorder of a system
<b>Chem 7.1 Physical Sciences (Chemistry)</b> High School Solutions, Rates of Reaction, and Equilibrium Describe the process by which solutes dissolve in solvents.	57	Solutions defined
	57	Solvents defined
	57	Solutes defined
	57	Dissolving process of solutes in solvents explained at molecular level
	58	Solubility explained
<b>Chem 7.2 Physical Sciences (Chemistry)</b> High School Solutions, Rates of Reaction, and Equilibrium Calculate concentration in terms of molarity.	58	Concentration of solutions explained
	59	Calculating solute and solution quantities
	60	Molarity defined
	60	Calculating the molarity of a solution
	61	Calculating solution quantities with molarity
<b>Chem 7.2 Physical Sciences (Chemistry)</b> High School Solutions, Rates of Reaction, and Equilibrium Use molarity to perform solution dilution and solution stoichiometry.	60	Molarity defined
	61	Using molarity to calculate solution quantities
	419	Dilution calculations
	464	Solution stoichiometry calculations

## A Natural Approach to Chemistry to the Massachusetts Learning Standards

Content Standard	Student text page	Detail
<b>Chem 7.3 Physical Sciences (Chemistry)</b> High School Solutions, Rates of Reaction, and Equilibrium Identify and explain the factors that affect the rate of dissolving (e.g., temperature, concentration, surface area, pressure, mixing).	274	Temperature's effect on solubility
	275	Factors affecting dissolving rate identified (surface area, mixing, pressure). Molecular level explanation of dissolving.
	276	Factors effecting solubility of gasses in liquids
<b>Chem 7.4 Physical Sciences (Chemistry)</b> High School Solutions, Rates of Reaction, and Equilibrium Compare and contrast qualitatively the properties of solutions and pure solvents (colligative properties such as boiling point and freezing point).	285	Molality defined
	285	Examples of colligative properties
	286	Colligative properties explained
	286	Practical example of antifreeze lowering freezing temperature
<b>Chem 7.5 Physical Sciences (Chemistry)</b> High School Solutions, Rates of Reaction, and Equilibrium Identify the factors that affect the rate of a chemical reaction (temperature, mixing, concentration, particle size, surface area, catalyst).	285	Explanation of how to calculate the drop in freezing temperature
	368	Factors affecting reaction rates
	369	The idea of rate explained
	370	Example of reaction with a measured rate
<b>Chem 7.6 Physical Sciences (Chemistry)</b> High School Solutions, Rates of Reaction, and Equilibrium Predict the shift in equilibrium when a system is subjected to a stress (LeChatelier's principle) and identify the factors that can cause a shift in equilibrium (concentration, pressure, volume, temperature).	371	Calculating average rate of reaction
	373	Molecular level example of when reactions explaining how rates are affected by collisions
	385	LeChatelier's principle explained
	386	Temperature identified as a factor than can cause a shift in equilibrium
	387	Concentration explained as a factor than can cause a shift in equilibrium
	388	Pressure and volume explained to be factors that can shift equilibrium

## A Natural Approach to Chemistry to the Massachusetts Learning Standards

Content Standard	Student text page	Detail
<p><b>Chem 8.1 Physical Sciences (Chemistry)</b></p> <p>High School</p> <p>Acids and Bases and Oxidation-Reduction Reactions</p> <p>Define the Arrhenius theory of acids and bases in terms of the presence of hydronium and hydroxide ions in water and the Bronsted-Lowry theory of acids and bases in terms of proton donors and acceptors.</p>	<p>412</p> <p>412</p> <p>413</p> <p>413</p>	<p>The Arrhenius theory of acids and bases explained</p> <p>Hydronium ion bonding process explained</p> <p>Bronsted-Lowry theory defined</p> <p>Example of nitric acid donating a proton</p>
<p><b>Chem 8.2 Physical Sciences (Chemistry)</b></p> <p>High School</p> <p>Acids and Bases and Oxidation-Reduction Reactions</p> <p>Relate hydrogen ion concentrations to the pH scale and to acidic, basic, and neutral solutions.</p>	<p>410</p> <p>411</p> <p>412</p> <p>416</p>	<p>The chemical nature of acids and bases</p> <p>Bases defined</p> <p>The importance of the H<sup>+</sup> ion</p> <p>The pH scale and examples of acids and bases</p>
<p><b>Chem 8.2 Physical Sciences (Chemistry)</b></p> <p>High School</p> <p>Acids and Bases and Oxidation-Reduction Reactions</p> <p>Compare and contrast the strengths of various common acids and bases (e.g., vinegar, baking soda, soap, citrus juice).</p>	<p>416</p> <p>423</p> <p>426</p>	<p>Household items pH shown from strong acids to strong bases</p> <p>Vinegar depicted as an example of an acid</p> <p>Example of ammonia as a weak base</p>
<p><b>Chem 8.3 Physical Sciences (Chemistry)</b></p> <p>High School</p> <p>Acids and Bases and Oxidation-Reduction Reactions</p> <p>Explain how a buffer works.</p>	<p>432</p> <p>433</p> <p>609</p>	<p>Common ions, conjugate bases and buffers defined</p> <p>Buffer capacity explained</p> <p>Example of bicarbonate being a buffer that helps counteract the effects of acid rain</p>

Content Standard	Student text page	Detail
<p><b>Chem 8.4 Physical Sciences (Chemistry)</b></p> <p>High School</p> <p>Acids and Bases and Oxidation-Reduction Reactions</p> <p>Describe oxidation and reduction reactions and give some everyday examples, such as fuel burning and corrosion. Assign oxidation numbers in a reaction.</p>	474	Everyday example of oxidation
	478	Oxidation reduction (redox) reactions defined
	479	Oxidation numbers explained with examples (rusting of iron, burning of methane)
	480	Rules for assigning oxidation numbers
	481	Application of oxidation number rules
	482	Finding oxidation numbers
	483	Fractional oxidation numbers