Pearson

Why Structure and Properties?

Dear Colleague,

In recent years, many chemistry professors, myself among them, have begun teaching their General Chemistry courses with an atoms-first approach. On the surface, this approach may seem like a mere reordering of topics, so that atomic theory and bonding theories come earlier than they do in the traditional approach. A rationale for this reordering is that students should understand the theory and framework behind the chemical "facts" they are learning. For example, in the traditional approach, students learn early that magnesium atoms tend to form ions with a charge of 2+. However, they don't understand *why* until much later (when they get to quantum theory). In an atoms-first approach, students learn quantum theory first and are therefore able to understand why magnesium atoms form ions with a charge of 2+ when they learn this fact. In this way, students see chemistry as a more coherent picture and not just a jumble of disjointed facts.

From my perspective, as an author and a teacher who teaches an atoms-first class, however, the atoms-first movement is more than just a reordering or topics. To me, the atoms-first movement is a result of the growing emphasis in chemistry courses on the two main ideas of chemistry, which are: 1) that matter is particulate, and 2) that the structure of the particles that compose matter determines its properties. In other words, the atoms-first movement is—at its core—an attempt to tell the story of chemistry in a more unified and thematic way. As a result, an atoms-first textbook must be more than a rearrangement of topics: it must tell the story of chemistry through the lens of the particulate model of matter. That is the goal I attempted to accomplish with *Chemistry: Structure and Properties*. Thanks to all of you who made the first edition the best-selling atoms-first book on the market. With this, the second edition, I continue to refine and improve on the approach taken in the first edition. My continuing hope is that students will recognize the power and beauty of the simple ideas that lie at the core of chemistry, and that they learn to apply them to see and understand the world around them in new ways.

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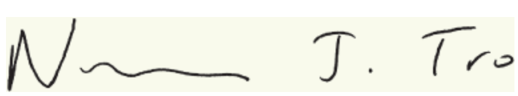


Structure and properties: A unified theme through

Structure and properties: A unified theme through the entire book

Section 1.1 – Introduction to the theme

1.1 A Particulate View of the World: Structure Determines Properties

As I sat in the "omnimover" and listened to the narrator's voice telling me that I was shrinking down to the size of an atom, I grew apprehensive but curious. Just minutes before, while waiting in line, I witnessed what appeared to be full-sized humans entering a microscope and emerging from the other end many times smaller. I was 7 years old and I was about to ride *Adventure Through Inner Space*, a Disneyland ride

Section 3.1 – How the structure of Al atoms determines the density of aluminum metal

The densities of elements and the radii of their atoms are examples of *periodic properties*. A **periodic property** is one that is generally predictable based on an element's position within the periodic table. In this chapter, we examine several periodic properties of elements, including atomic radius, ionization energy, and electron affinity. As we do, we will see that these properties—as well as the overall arrangement of the periodic table—are explained by quantum-mechanical theory, which we first examined in Chapter 2. *Quantum-mechanical theory explains the electronic structure of atoms—this in turn determines the properties of those atoms.*

Section 3.5 – How atomic structure determines the properties of the elements

3.5 Electron Configurations and Elemental Properties

As we discussed in Section 3.4, *the chemical properties of elements are largely determined by the number of valence electrons the elements contain.* The properties of elements are periodic because the number of valence electrons is periodic. Mendeleev grouped elements into families (or columns) based on observations about their properties. We now know that elements in a family have the same number of valence electrons. In other words, elements in a family have similar properties because they have the same number of valence electrons.

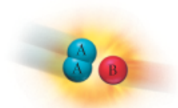
Section 14.2 – How reaction rates depend of the structure of the reacting particles

14.2 Rates of Reaction and the Particulate Nature of Matter

We have seen throughout this book that matter is composed of particles (atoms, ions, and molecules). The simplest way to begin to understand the factors that influence a reaction rate is to think of a chemical reaction as the result of a collision between these particles. This is the basis of *the collision model*, which we cover in more detail in Section 14.6. For example, consider the following simple generic reaction occurring in the gaseous state:

$$\mathrm{A{-}A} + \mathrm{B} \longrightarrow \mathrm{A{-}B} + \mathrm{A}$$

According to the collision model, the reaction occurs as a result of a collision between A-A particles and B particles.



CHAPTER 3

Periodic Properties of the Elements

GREAT ADVANCES IN SCIENCE occur not only when a scientist sees something new, but also when a scientist sees something everyone else has seen in a new way. That is what happened in 1869 when Dmitri Mendeleev, a Russian chemistry professor, saw a pattern in the properties of elements. Mendeleev's insight led to the development of the periodic table. Recall from Chapter 1 that theories explain the underlying reasons for observations. If we think of Mendeleev's periodic table as a compact way to summarize a large number of observations, then quantum mechanics is the theory that explains the underlying reasons. Quantum mechanics explains how electrons are arranged in an element's atoms, which in turn determines the element's properties. Because the periodic table is organized according to those properties, quantum mechanics elegantly accounts for Mendeleev's periodic table. In this chapter, we see a continuation of this book's theme—the properties of matter (in this case, the elements in the periodic table) are explained by the properties of the particles that compose them (in this case, atoms and their electrons).

> "It is the function of science to discover the existence of a general reign of order in nature and to find the causes governing this order."
>
> —Dmitri Mendeleev (1834–1907)

3.1 Aluminum: Low-Density Atoms Result in Low-Density Metal

Look out the window of almost any airplane and you will see the large sheets of aluminum that compose the aircraft's wing. In fact, the majority of the plane is most likely made out of aluminum. Aluminum has several properties that make it suitable for airplane construction, but among the most important is its low density. Aluminum has a density of only 2.70 g/cm^3. For comparison, iron's density is 7.86 g/cm^3, and platinum's density is 21.4 g/cm^3. Why is the density of aluminum metal so low?

The density of aluminum metal is low because the density of an aluminum atom is low. Few metal atoms have a lower mass-to-volume ratio than aluminum, and those that do can't be used in airplanes for other reasons (such as their high chemical reactivity). Although the *arrangements* of atoms in a solid must also be considered when evaluating the density of the solid, the mass-to-volume ratio of the composite atoms

Section 16.4 – How the structure of an acid determines its strength

16.4 Acid Strength and Molecular Structure

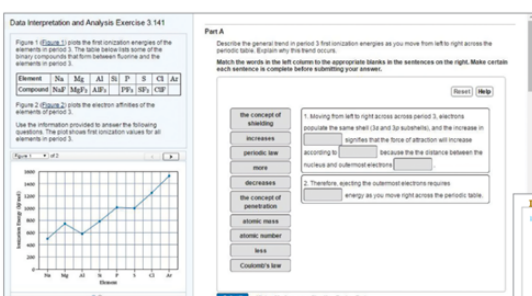
We have learned that a Brønsted–Lowry acid is a proton [H^+] donor. Now we explore why some hydrogen-containing molecules act as proton donors while others do not. In other words, we explore *how the structure of a molecule affects its acidity*. Why is H_2S acidic while CH_4 is not? Or why is HF a weak acid while HCl is a strong acid? We divide our discussion about these issues into two categories: binary acids (those containing hydrogen and only one other element) and oxyacids (those containing hydrogen bonded to an oxygen atom that is bonded to another element).

Section 18.4 – How the structure of a molecule determines its entropy

18.7 Entropy Changes in Chemical Reactions: Calculating ΔS°_{rxn}

We now turn our attention to predicting and quantifying entropy and entropy changes in a sample of matter. As we examine this topic, we again encounter the theme of this text: *Structure determines properties.* In this case, the property we are interested in is entropy. In this section we see how the structure of the particles that compose a particular sample of matter determines the entropy that the sample possesses at a given temperature and pressure.

Build students' 21st-century skills to set them up for success.



DATA INTERPRETATION AND ANALYSIS

108. In April 2014, in an effort to save money, officials in Flint, Michigan, changed their water source from Lake Huron to the Flint River. In subsequent months, residents began complaining about the quality of the water, and General Motors (which has an engine plant in Flint) stopped using the water in manufacturing because of its corrosiveness. That corrosiveness was causing problems that would soon fuel a national outrage. The water flowed through pipes to taps in homes, and as it flowed through the pipes, many of which contained lead, the corrosive water became contaminated with lead. Routine monitoring of the tap water in select homes did not reveal the magnitude of the problem because samples were collected only after preflushing the tap (allowing the water to run for a time).

A Virginia Tech professor and his students began an independent test of the water coming from Flint's taps and got much different results by analyzing the water that initially came from the taps (first draw). Their results—which showed elevated lead levels in the tap water—ultimately forced officials to switch back to the Lake Huron water source.

The following table shows a set of data collected by the Virginia Tech team. The lead levels in water are expressed in units of parts per billion (ppb). 1 ppb = 1 g Pb/10^9 parts solution. Examine the data and answer the questions that follow.

a. Determine the average value of lead for first draw, 45-second flush, and 2-minute flush (round to three significant figures).

b. Do the data support the idea that running the tap water before taking a sample made the lead levels in the water appear lower? Why might this occur?

c. The EPA requires water providers to monitor drinking water at customer taps. If lead concentrations exceed 15 ppm in 10% or more of the taps sampled, the water provider must notify the customer and take steps to control the corrosiveness of the water. If the water provider in Flint had used first-draw samples to monitor lead levels, would they have been required to take action by EPA requirements? If the Flint water provider used 2-min flush samples, would they have had to take action? Which drawing technique do you think more closely mimics the way residents actually use their water?

d. Using the highest value of lead from the first-draw data set, and assuming a resident drinks 2 L of water per day, calculate the mass of lead that the resident would consume over the course of one year. (Assume the water has a density of 1.0 g/mL.)

Lead Levels in Samples of Flint Tap Water

Sample #	Lead Level 1[st] draw (ppb)	Lead Level 45 sec flush (ppb)	Lead Level 2 min flush (ppb)
1	0.344	0.226	0.145
2	8.133	10.77	2.761
3	1.111	0.11	0.123

4	8.007	7.446	3.384
5	1.961	0.048	0.035
6	7.2	1.4	0.2
7	40.63	9.726	6.132
8	1.1	2.5	0.1
9	10.6	1.038	1.294
10	6.2	4.2	2.3
11	4.358	0.822	0.147
12	24.37	8.796	4.347
13	6.609	5.752	1.433
14	4.062	1.099	1.085
15	29.59	3.258	1.843

Source: FlintWaterStudy.org (2015) "Lead Results from Tap Water Sampling in Flint, Michigan, during the Flint Water Crisis"

Data Interpretation and Analysis Questions at the end of each chapter allow students to use real data to develop 21st-century problem-solving skills. These in-depth exercises give students practice reading graphs, digesting tables, and making data-driven decisions. Find these questions at the end of every chapter as well as in the item library of MasteringChemistry™.

QUESTIONS FOR GROUP WORK

Active Classroom Learning

Discuss these questions with the group and record your consensus answer.

136. In a complete sentence, describe the relationship between shielding and penetration.

137. Play a game to memorize the order in which orbitals fill. Have each group member in turn state the name of the next orbital to fill and the maximum number of electrons it can hold (for example, "1s two," "2s two," "2p six"). If a member gets stuck, other group members can help, consulting Figure 3.8 and the accompanying text summary if necessary. However, when a member gets stuck, the next player starts back at "1s two." Keep going until each group member can list all the orbitals in order up to "6s two."

138. Sketch a periodic table (without element symbols). Include the correct number of rows and columns in the *s*, *p*, *d*, and *f* blocks. Shade in the squares for elements that have irregular electron configurations.

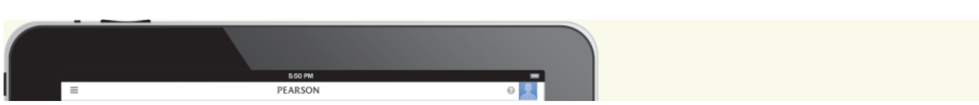
139. In complete sentences, explain: a) why Se^{2-} and Br^- are about the same size; b) why Br^- is slightly smaller than Se^{2-}; and c) which singly charged cation you would expect to be approximately the same size as Se^{2-} and Br^- and why.

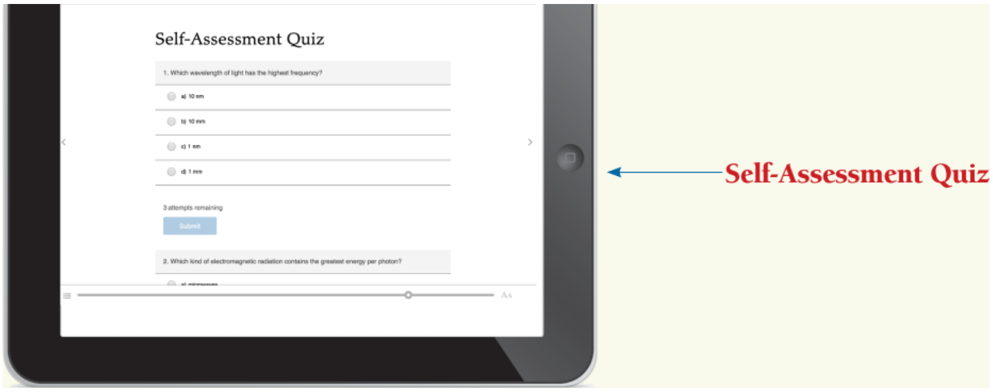
140. Have each member of your group sketch a periodic table indicating a periodic trend (atomic size, first ionization energy, metallic character, etc.). Have each member present his or her table to the rest of the group and explain the trend based on concepts such as orbital size or effective nuclear charge.

Questions for Group Work allow students to collaborate and apply problem-solving skills on questions covering multiple concepts. The questions can be used in or out of the classroom, and the goal is to foster collaborative learning and encourage students to work together as a team to solve problems. All questions for group work are pre-loaded into Learning Catalytics™ for ease of assignment.

Engage students in chemistry like never before with an interactive eText 2.0.

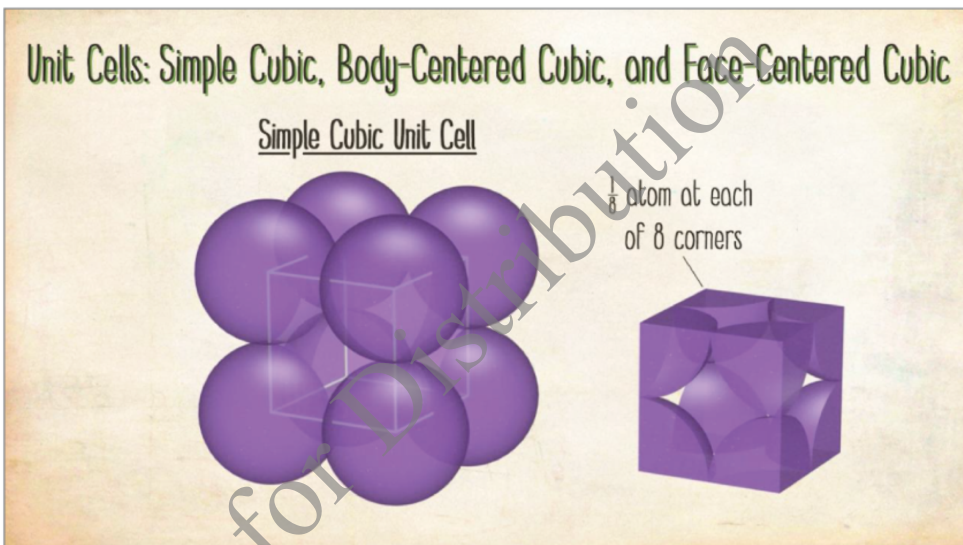
NEW INTERACTIVES! Conceptual Connections and Self-Assessment Quizzes are now embedded for students within eText 2.0! In the eText, these activities are brought to life, allowing students to study on their own and test their understanding in real-time. Complete with answer-specific feedback, these interactives help students extinguish misconceptions and deepen their understanding of important concepts and topics. Quizzes are algorithmically coded into MasteringChemistry™ to allow students to practice the types of questions they will encounter on the ACS or other exams. All Conceptual Connections are also embedded and interactive in eText 2.0 and are assignable activities MasteringChemistry™.



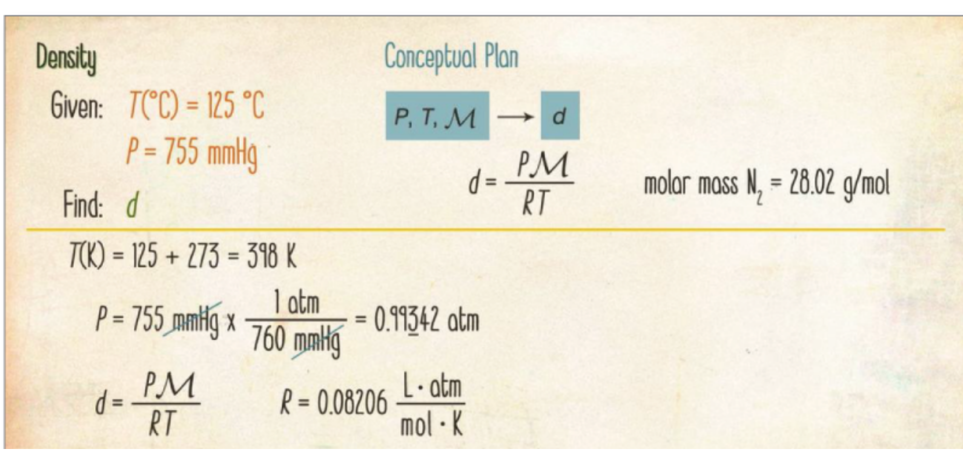


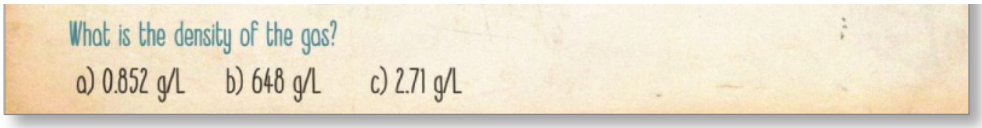
Embedded Interactive videos create a dynamic learning experience in eText 2.0.

Key Concept Videos combine artwork from the textbook with 2D and 3D animations to create a dynamic on-screen viewing and learning experience. These short videos include narration and brief live-action clips of author Nivaldo Tro explaining the key concepts of each chapter of *Chemistry: Structure and Properties*. All Key Concept Videos are embedded and interactive in and are assignable activities MasteringChemistry™.



Interactive Worked Examples are digital versions of select worked examples from the text that make Tro's unique problem-solving strategies interactive. These instruct students how to break down problems using Tro's "Sort, Strategize, Solve, and Check" technique. These problems are incorporated into the reading experience and are available in MasteringChemistry™ as assignable activities.





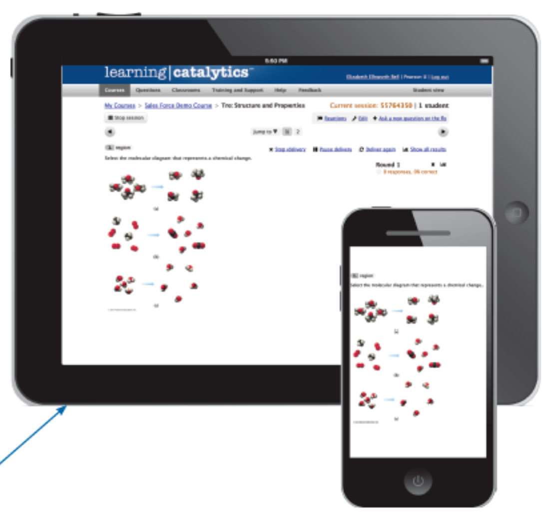
Teaching Modules and Learning Catalytics™ in MasteringChemistry™ ensure student engagement before, during, and after class.

Ready-To-Go Teaching Modules provide instructors with easy-to-use tools for teaching the toughest topics in chemistry. These modules demonstrate how your colleagues effectively use all the resources Pearson has to offer to accompany *Chemistry: Structure and Properties*.

Ready-to-Go Teaching Modules were created for and by instructors to provide easy-to-use assignments for before, during, and after class. Assets include in-class activities and questions in Learning Catalytics™.

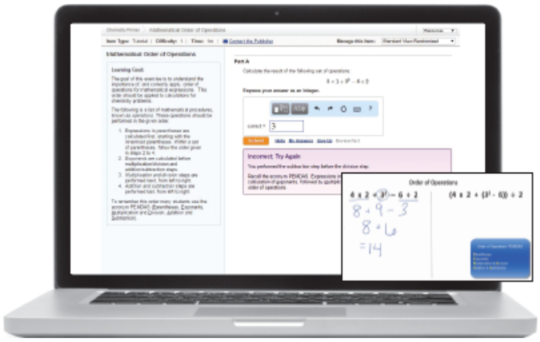
With questions specific to Tro's *Structure and Properties*, **Learning Catalytics™** generates class discussion, customizes your lecture, and promotes peer-to-peer learning with real-time analytics. MasteringChemistry™ with eText 2.0 now provides Learning Catalytics™—the interactive student response tool that uses students' smartphones, tablets, or laptops to engage them in more sophisticated tasks and individual and group problem-solving. Instructors can:

- NEW! Upload a full PowerPoint® deck for easy creation of slide questions.
- NEW! Team names are no longer case sensitive.
- Help students develop critical thinking skills.
- Monitor responses to find out where students are struggling.
- Rely on real-time data to adjust teaching strategy.
- Automatically group students for discussion, teamwork, and peer-to-peer learning.



Tro's Questions for Group Work can be found in Learning Catalytics™ so that students can work these questions in groups.

The Chemistry Primer and Dynamic Study modules encourage students to come to class prepared.



NEW! The Chemistry Primer helps students remediate their chemistry math skills and prepare for their first college chemistry course.

- Pre-built Assignments get students up-to-speed at the beginning of the course.
- Math is covered in the context of chemistry, basic chemical literacy, balancing chemical equations, mole theory, and stoichiometry.
- Scaled to students' needs, remediation is only suggested to students that perform poorly on initial assessment.
- Remediation includes tutorials, wrong-answer specific feedback, video instruction, and step-wise scaffolding to build students' abilities.

66 Dynamic Study Modules help students study effectively on their own by continuously assessing their activity and performance in real time. Here's how it works: students complete a set of questions with a unique answer format that also asks them to indicate their confidence level. Questions repeat until the student can answer them all correctly and confidently. Study modules are available as graded assignments prior to class and are accessible on smartphones, tablets, and computers.

Topics include:

- Key math skills
- General chemistry concepts such as phases of matter, redox reactions, and acids and bases
- Nuclear chemistry
- Organic and biochemistry

Instructor and student supplements

Solutions Manual	0134460693 / 9780134460697 The solution manual contains complete, step-by-step solutions to end-of-chapter problems.
Student's Selected Solutions Manual	0134460677 / 9780134460673 The selected solution manual for students contains complete, step-by-step solutions to selected odd-numbered end-of-chapter problems.
Instructor Resource Manual (Download only)	0134549422 / 9780134549422 For download only, the *Instructor Resource Manual* is intended as a resource for both new and experienced teachers. It includes learning objectives, chapter reviews, and answers to the texts' questions. The *Instructor Resource Manual* also includes discussion topics and advice about how to integrate visual supplements (including the on-line resources), questions and various other ideas for the classroom.
Instructor Resource Materials (Download only)	0134460723 / 9780134460727 The material available for download includes: • All illustrations, tables, and photos from the text in JPEG format • Four pre-built PowerPoint® Presentations (lecture, worked examples, images, CRS/clicker questions) • Interactive animations, movies, and 3D molecules • TestGen computerized software with the TestGen version of the Testbank • Word files of the Test Item File
Laboratory Manual	0134616456 / 9780134616452 Prepared by Daphne Norton of the University of Georgia. This manual contains over twenty experiments designed to complement an atoms first approach. You can also customize these labs through Pearson Custom Library. For more information, visit http://www.pearsoncustom.com/custom-library.
Study Guide	0134460685 / 9780134460680 This *Study Guide* was written specifically to assist students using *Structure and Properties*. It presents the major concepts, theories, and applications discussed in the text in a comprehensive and accessible manner for students. It contains learning objectives, chapter summaries and outlines, as well as examples, self tests and concept questions.
MasteringChemistry™ with Pearson eText 2.0—Instant Access	0134565096 / 9780134565095 This product includes all of the resources of MasteringChemistry™ plus the now fully mobile eText 2.0. eText 2.0 mobile app offers offline access and can be downloaded for most iOS and Android phones/tablets from the Apple App Store or Google Play. Added integration brings videos and other rich media to the student's reading experience. MasteringChemistry™ from Pearson is the leading online homework, tutorial, and assessment system, designed to improve results by engaging students with powerful content. Instructors ensure students arrive ready to learn by assigning educationally effective content and encourage critical thinking and retention with in-class resources such as Learning Catalytics™. Ready-to-Go Teaching Modules created for and by instructors provide a guide for easy-to-use assignments for before and after class plus in-class activities and questions in Learning Catalytics™. Students can further master concepts through traditional and adaptive homework assignments that provide hints and answer-specific feedback. The Mastering™ gradebook records scores for all automatically-graded assignments in one place, while diagnostic tools give instructors access to rich data to assess student understanding and misconceptions. **URL:** http://www.masteringchemistry.com
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