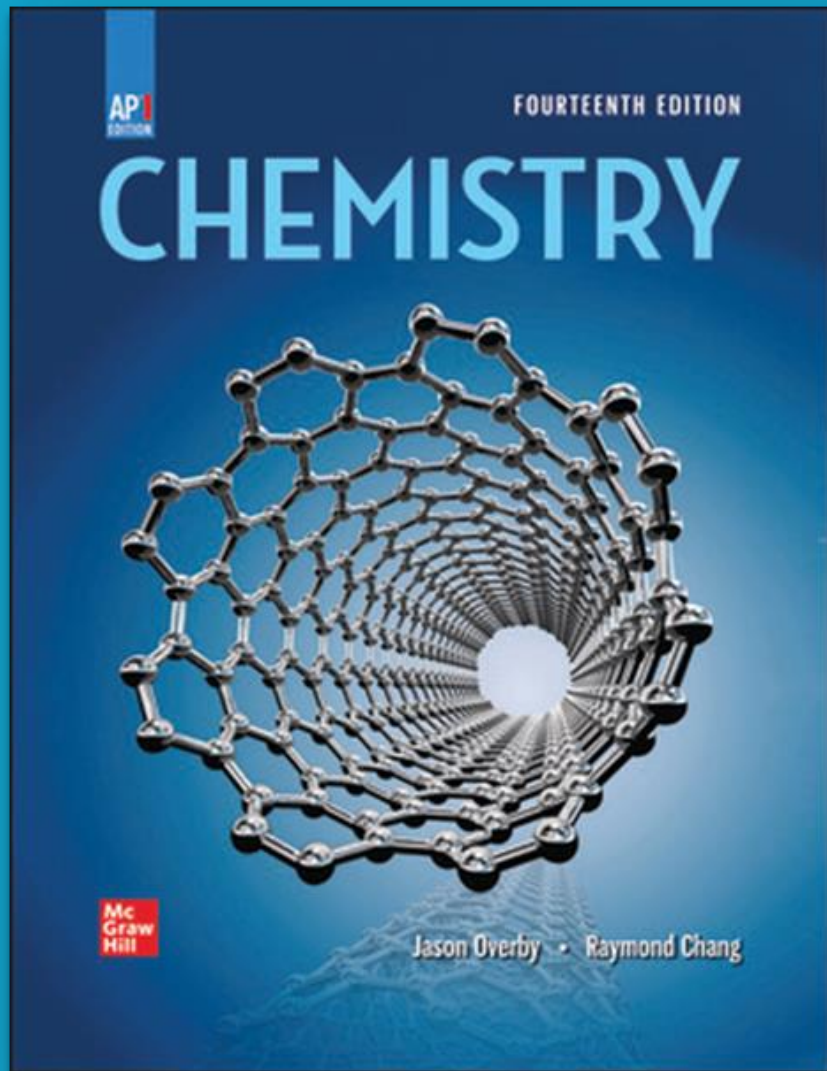


# *Chemistry,* **AP Edition**

Chang

©2023

14<sup>th</sup> edition



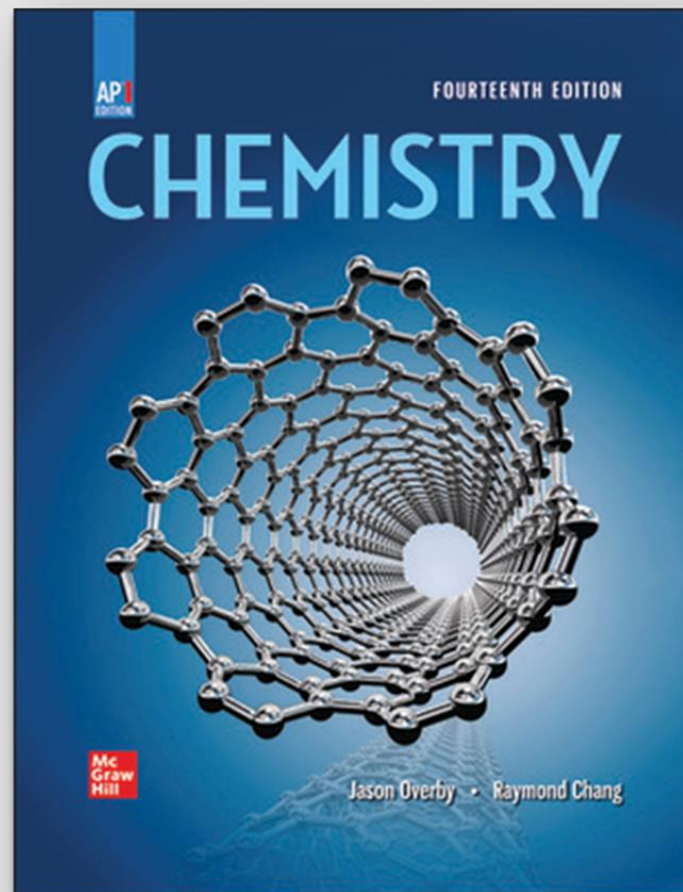
# *Chemistry,* **AP Edition**

Chang

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14<sup>th</sup> edition

**Accessible.  
Adaptive.  
Aligned.**



## Features

### Connecting

The fourteenth edition connects chemical concepts to the world around us, showing how chemistry plays in our daily life and the connections between

## Teacher Resources

McGraw Hill offers a variety of resources and tools to support your teaching, including dynamic reporting, content updates, and more, making it easier than ever to find the resources you need.

### Teacher Resources

- **AP Teacher Manual.** The AP Teacher Manual, written by Cumming, illustrates the AP Framework and provides a comprehensive Teacher Manual is available for download.
- **AP Assessment Bank.** The AP Assessment Bank helps provide students with practice questions and free response questions.
- **Content Review Tools.** The Content Review Tools are designed to help create chapter exams and quizzes.
- **ALEKS®.** ALEKS is a digital subscription service that determines exactly what a student needs to learn and instructs each student on their path.
- **PowerPoints®.** The AP Teacher Manual includes a complete set of PowerPoints for each chapter to structure classroom instruction.
- **Instructor's Solutions Manual.** The Instructor's Solutions Manual provides the end-of-chapter answers to all problems.
- **Virtual Labs.** VIRTUAL Labs are interactive simulations that replace, prepare, or enhance practical and conceptual lab experiences, including adaptive pre-lab assignments.

## Student Resources

- **eBook.** The interactive eBook offers built-in bookmarking, highlighting, note taking, and text-to-speech capabilities. The content can be downloaded with McGraw Hill's free ReadAnywhere app for anytime, anywhere, from-any-device access.
- **SmartBook®.** SmartBook's adaptive technology highlights key concepts, delivers immediate practice opportunities, provides instant and guided feedback, and targets gaps in knowledge. Students have access to individualized instruction and meaningful remediation anytime, anywhere, from any device.
- **Videos and Animations.** Instructor-narrated videos explain key concepts and work challenging problems. Full-color animations illustrate important processes to help augment classroom instruction.

### Additional Support

**5 Steps to a 5: AP Chemistry.** This resource, available to accompany *Chemistry*, guides students through an easy to follow, effective 5-step study plan to help them build the skills, knowledge, and test-taking confidence for AP Exam Success. Expertly authored by veteran AP teachers and presented in lock-step alignment to the College Board outcomes, *5 Steps to a 5* offers:

- The 5 Minutes to a 5 feature that includes 180 "bellringers" and activities to reinforce the most vital course material—one for every day of the school year,
- hundreds of practice exercises with thorough answer explanations,
- comprehensive overview of the AP Chemistry Exam format

### CHAPTER 1

### CHAPTER 1

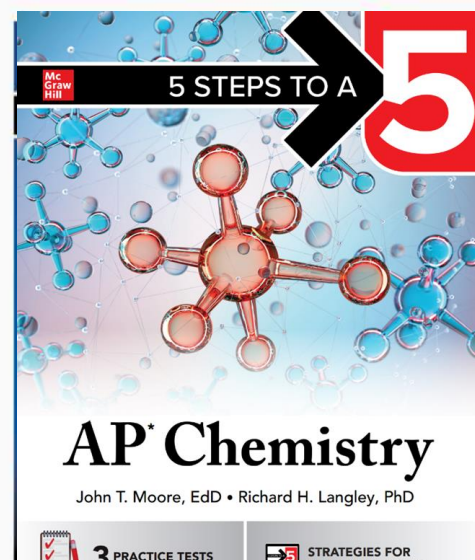
- 7.1 From Old to New
- 7.2 The Periodic Table
- 7.3 Bohr's Model of the Hydrogen Atom
- 7.4 The Bohr Model of the Atom
- 7.5 Quantum Mechanics
- 7.6 Quantum Mechanics
- 7.7 Atomic Structure
- 7.8 Electromagnetic Radiation
- 7.9 The Balmer Series
- 7.10 Lower Levels of the Balmer Series
- 7.11 Nuclear Chemistry
- 7.12 Applications

Imaging electronic levels in the fundamental principles of quantum mechanics where particles are the discrete objects.

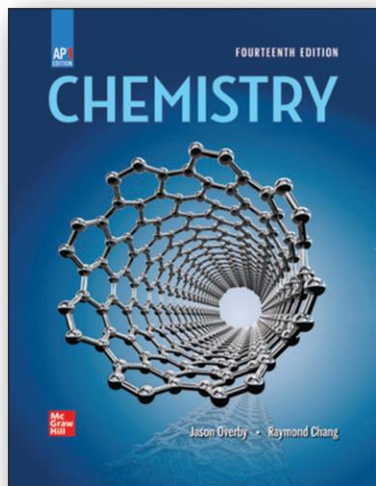
### AP A Look

How do you know if a reaction is spontaneous? This is a question that can be answered by observing the effect of a catalyst. For example, light energy provides a catalyst for the reaction of hydrogen and oxygen. Other studies, like the study of the reaction of hydrogen and oxygen, provide evidence for the spontaneity of a reaction. These studies show that the reaction of hydrogen and oxygen is spontaneous, not only in the laboratory but also in the natural world.

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Graw  
Hill

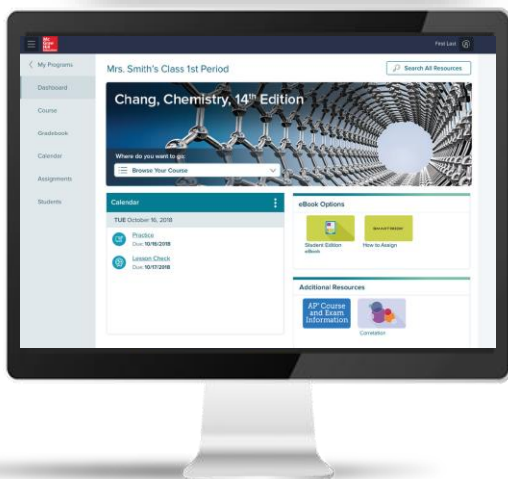






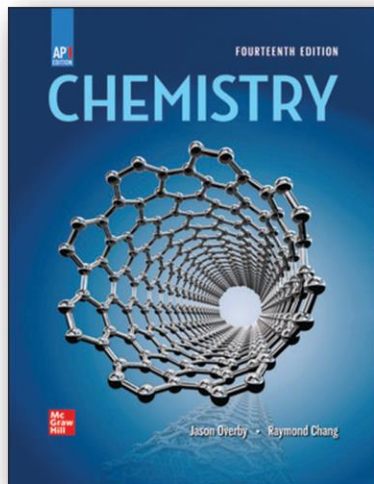
## *Chemistry, AP Edition* Chang, ©2023, 14e

- Accessible to learners of all levels
- Full alignment to AP Framework
- Robust digital resources
- SmartBook: **A McGraw Hill Difference**
- Unmatched instructional support

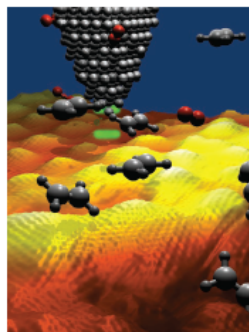


## Digital Integration

- ✓ **MAXIMUM ACCESS FOR STUDENTS:**  
**Full LMS Integration with Grade Passback & Sync**
- ✓ **FULL** Integration/ Sync Across All devices
- ✓ **Online, Print, or Hybrid. You have Options.**



- Introduction to AP Chemistry
- Highlighted AP Units
- AP Chapter Summary
- AP Chapter Review



Brookhaven National Laboratory/  
Science Source

## 1 Introduction to AP Chemistry 1

### AP Unit 1 Atomic Structure and Properties

- 1.1 Chemistry: A Science for the Twenty-First Century 2
- 1.2 Introducing the AP Curriculum Framework 3
- 1.3 Introducing the AP Science Practices 7
- 1.4 Classification of Matter 8
- 1.5 Review: The Scientific Method 14
- CHEMISTRY in Action**  
The Search for the Higgs Boson 16
- 1.6 Review: Measurements 17
- CHEMISTRY in Action**  
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- 1.7 Review: Handling Numbers 21
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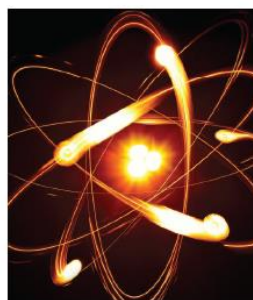
### AP Unit 1 Atomic Structure and Properties

- 2.1 The Atomic Theory 41
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Distribution of Elements on Earth and in Living Systems 53
- 2.5 Molecules and Ions 54
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- 2.8 Introduction to Organic Compounds 70

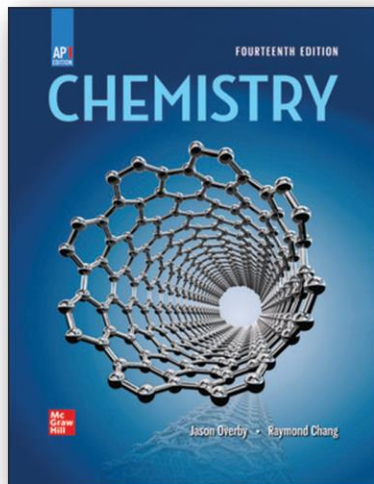
AP Chapter Summary Unit 1 71

Questions & Problems 72

AP Chapter Review Unit 1 AP77–AP78



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# Chapter Openers

## CHAPTER

# 7

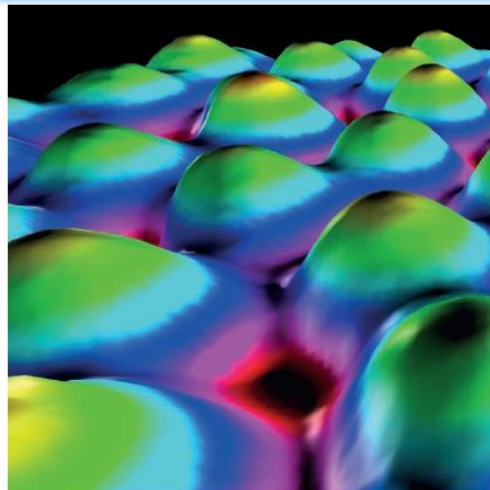
## Quantum Theory and the Electronic Structure of Atoms

### CHAPTER OUTLINE

- 7.1 From Classical Physics to Quantum Theory
- 7.2 The Photoelectric Effect
- 7.3 Bohr's Theory of the Hydrogen Atom
- 7.4 The Dual Nature of the Electron
- 7.5 Quantum Mechanics
- 7.6 Quantum Numbers
- 7.7 Atomic Orbitals
- 7.8 Electron Configuration
- 7.9 The Building-Up Principle

AP Unit 1 Atomic Structure and Properties

AP Unit 3 Intermolecular Forces and Properties



Imaging atomic surfaces illustrates one of the fundamental principles of quantum mechanics where precise measurements are on the atomic scale are not possible.  
Andrew Dunn/Alamy Stock Photo



### A Look Ahead

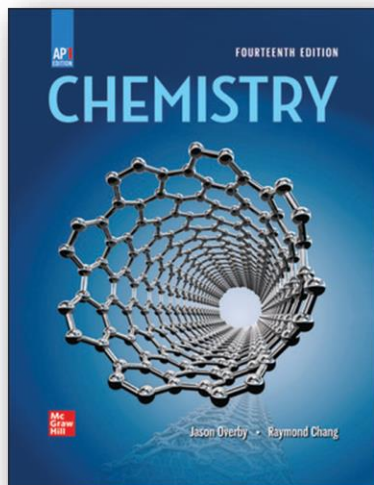
How do we know where electrons are around the nucleus of an atom? This is a “black box” problem, where the inner structure cannot be viewed directly and can only be solved by observing what goes in and what comes out as we prod and poke the system. Light energy emitted by atoms in a high-energy state provides clues to solving the inner structure of the atom. Other studies including the photoelectric effect (Topic 3.12) and the behavior of atoms in a magnetic field provide evidence for the arrangement of electrons within the atom (Topic 1.5). Results of these experiments led to a “remodeling” of the atom during the 1900s, with each successive model building upon earlier models. Our current model, the Quantum Theory, not only explains the production of light in neon signs but also the periodic properties

of the elements (Topic 1.7), the bonds and shapes of molecules and ultimately, the behavior of all matter.

As you read the chapter, think about these Essential Questions:

1. What is Planck's quantum theory? 1.7
2. What is the photoelectric effect? 3.12
3. What is the Bohr model of the hydrogen atom? 1.5
4. Can we determine the exact location of an electron bound to a nucleus? Why or why not? 1.5
5. What is an orbital? What is an electron configuration? What is shielding? What is the Aufbau principle? 1.5





# Accessible Instruction

## 7.1 From Classical Physics to Quantum Theory

### Learning Objectives

- Summarize the properties of waves in terms of wavelength and amplitude.
- Interconvert the wavelength and frequency of electromagnetic radiation.

### Example 7.3

The work function of cesium metal is  $3.42 \times 10^{-19}$  J. (a) Calculate the minimum frequency of light required to release electrons from the metal. (b) Calculate the kinetic energy of the ejected electron if light of frequency  $1.00 \times 10^{15} \text{ s}^{-1}$  is used for irradiating the metal.

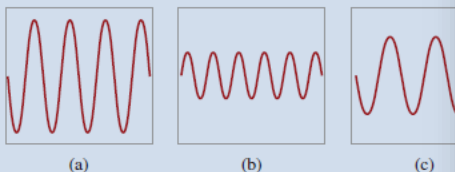
**Strategy** (a) The relationship between the work function of an element and the frequency of light is given by Equation (7.4). The minimum frequency of light needed to dislodge an electron is the point where the kinetic energy of the ejected electron is zero.

### Summary of Concepts & Facts

- The quantum theory developed by Planck successfully explains the emission of radiation by heated solids. The quantum theory states that radiation is emitted by atoms and molecules in small discrete amounts (quanta) over a continuous range. This behavior is governed by the relationship  $E = h\nu$ , where  $E$  is the energy of the radiation,  $h$  is Planck's constant, and  $\nu$  is the frequency of the radiation. Energy is always emitted in whole-number multiples of  $h\nu$  ( $1 h\nu, 2 h\nu, 3 h\nu, \dots$ ).

### Review of Concepts & Facts

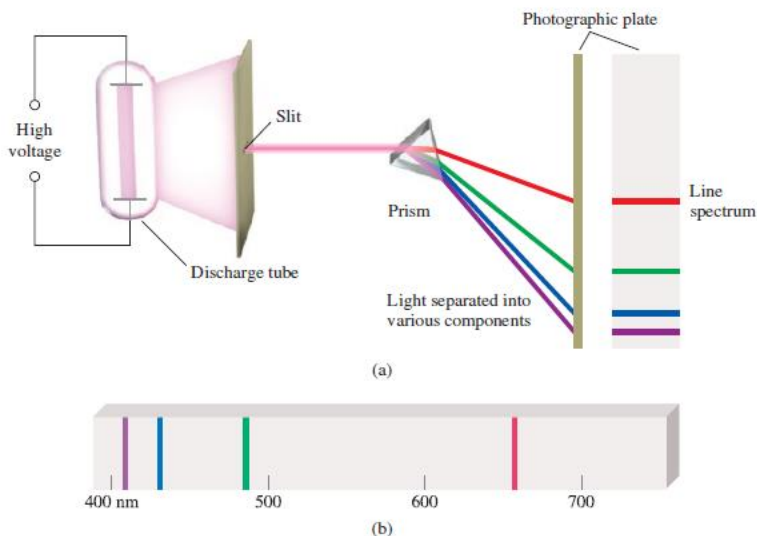
**7.1.1** Which of the waves (a)–(c) has (i) the highest frequency, (ii) the longest wavelength, (iii) the greatest amplitude?



**7.1.2** Why is radiation only in the UV but not the visible or infrared responsible for sunbathing?

284

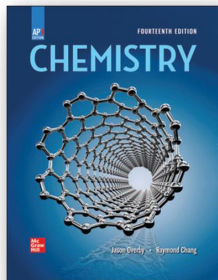
Chapter 7 • Quantum Theory and the Electronic Structure of Atoms



**Figure 7.10** (a) An experimental arrangement for studying the emission spectra of atoms and molecules. The gas under study is in a discharge tube containing two electrodes. As electrons flow from the negative electrode to the positive electrode, they collide with the gas. This collision process eventually leads to the emission of light by the atoms (or molecules). The emitted light is separated into its components by a prism. Each component color is focused at a definite position, according to its wavelength, and forms a colored image of the slit on the photographic plate. The colored images are called spectral lines. (b) The line emission spectrum of hydrogen atoms.



**Figure 7.11** Color emitted by hydrogen atoms in a discharge tube. The color observed results from the combination of the colors from the combination of the colors emitted in the visible spectrum. SPL/Science Source



## Real-World Applications

### Applying the Science Practices

**AP**

## Interpreting, Modeling, & Estimating

## Science Practices

7.155 Atoms of an element have only two accessible excited states. In an emission experiment, however, three spectral lines were observed. Explain. Write an equation relating the shortest wavelength to the other two wavelengths.

7.156 According to Wien's law, the wavelength of maximum intensity in blackbody radiation,  $\lambda_{\text{max}}$ , is given by

$$\lambda_{\text{max}} = \frac{b}{T}$$

where  $b$  is a constant ( $2.898 \times 10^6 \text{ nm} \cdot \text{K}$ ) and  $T$  is the temperature of the radiating body in kelvins. (a) Estimate the temperature at the surface of the sun. (b) How are astronomers able to determine the temperature of stars in general? (See Problem 7.150 for a definition of blackbody radiation.)

7.157 Only a fraction of the electrical energy supplied to an incandescent-tungsten lightbulb is converted to visible light. The rest of the energy shows up as infrared radiation (that is, heat). A 60-W lightbulb converts about 15.0% of the energy supplied to it

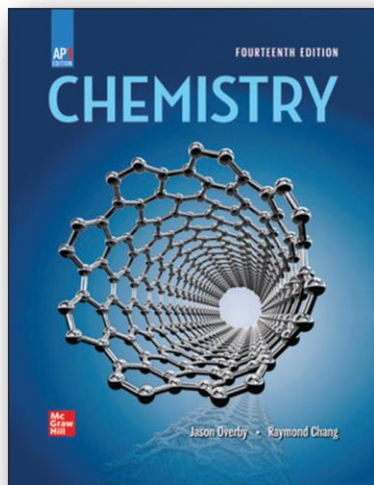
into visible light. Roughly how many photons are emitted by the lightbulb per second? ( $1 \text{ W} = 1 \text{ J/s}$ .)

7.158 Photosynthesis makes use of photons of visible light to bring about chemical changes. Explain why heat energy in the form of infrared photons is ineffective for photosynthesis. (*Hint:* Typical chemical bond energies are 200 kJ/mol or greater.)

7.159 A typical red laser pointer has a power of 5 mW. How long would it take a red laser pointer to emit the same number of photons emitted by a 1-W blue laser in 1 s? ( $1 \text{ W} = 1 \text{ J/s}$ .)

7.160 Referring to the Chemistry in Action essay "Quantum Dots" in Section 7.9, estimate the wavelength of light that would be emitted by a cadmium selenide (CdSe) quantum dot with a diameter of 10 nm. Would the emitted light be visible to the human eye? The diameter and emission wavelength for a series of quantum dots are given here.

Diameter (nm)	2.2	2.5	3.3	4.2	4.9	6.3
Wavelength (nm)	462	503	528	560	583	626



## Features for AP Success



### STUDENT HOT SPOT

Student data indicate you may struggle with this content. View the following video, "Converting Element Mass into Moles and Atoms," to make sure you understand the concept before moving on.



### Student Hot Spot

Student data indicate you may struggle with understanding electron configurations. Access your eBook for additional Learning Resources on this topic.

Element Conversions 107.9  $\frac{\text{g}}{\text{mol}}$

many moles and atoms are in 47.35g silver?

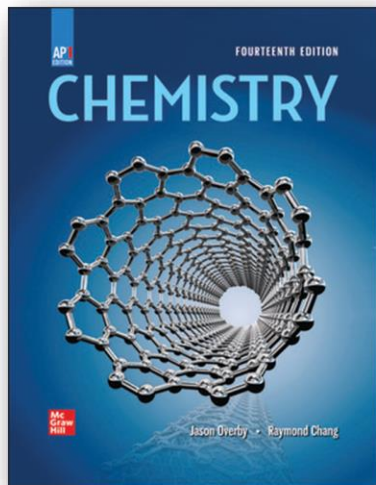
$$\frac{47.35 \text{ g Ag}}{107.9 \frac{\text{g}}{\text{mol}}} = 0.4388 \text{ mol Ag}$$

$$\frac{47.35 \text{ g Ag}}{107.9 \frac{\text{g}}{\text{mol}}} \times 6.022 \times 10^{23} \frac{\text{atoms}}{\text{mol}} = 2.643 \times 10^{23} \text{ atoms Ag}$$

- c. There would be more electrons removed than in the first trial since this higher energy source would remove core electrons.
- d. There would be electrons removed from only the sec-

- b.  $3.0 \times 10^{-5} M$
- c.  $4.0 \times 10^{-5} M$
- d.  $8.0 \times 10^{-5} M$





## Additional AP Exam Support

- “Bellringers” and activities to reinforce vital course material
- Full-length practice tests that mimic the actual AP Exam
- Rubrics and overviews for essay sections and FRQs



## AP\* Chemistry

John T. Moore, EdD • Richard H. Langley, PhD

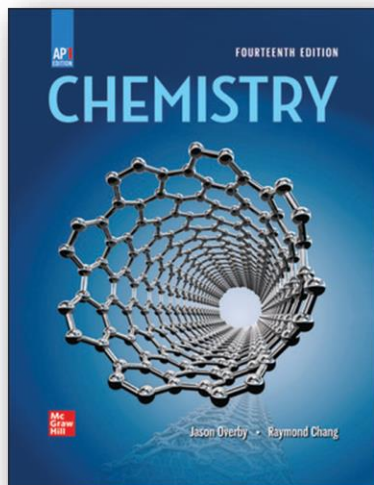


**3** PRACTICE TESTS



STRATEGIES FOR  
AP EXAM SUCCESS





# Dynamic Digital Resources

- Interactive eBook
- SmartBook assignments
- Activities and assessments
- Videos to explain key concepts and work challenging problems
- Full-color animations

**INQUIRY ACTIVITY**

Chapter 2 Chemistry Interactive Question Bank

Chapter 2 Chemistry Content Review Assessment

Question 1 of 23

and electrons  $E$  in one atom of  $^{238}\text{U}$ .

gram of amount-mass-number

ject as  $A$ ,

0:26 / 0:28

magnetic and electric fields

mass-to-charge

smaller particles

nucleus

2. Find and outline three different examples of processes.

Clear

0.00

Add 5.00 mL of NaOH

0.200M NaOH

11.17

pH

50.00

13.00

11.00

9.00

7.00

5.00

3.00

1.00

0

0 5 10 15 20 25 30 35 40

Volume of NaOH added

$\text{H}^+$

$\text{Cl}^-$

$\text{Na}^+$

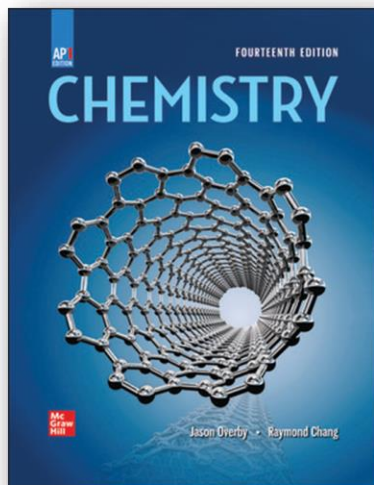
$\text{OH}^-$

$\text{H}_2\text{O}$

2:03 / 3:20

1x

CC



# Interactive eBook

CHAPTER  
2: Atoms, Molecules, and Ions

Show Chapter Info 27 Jul 2021 - 30 Jul 2021 Expand All

Student Resources

eBook Chapter 2 SmartBook Chapter 2

Assign Assign

Chapter Assignments

AP Chemistry Ch. 2 Test Chapter 2 Chemistry Content Review Assessment Chapter 2 Chemistry Interactive Question Bank

Assign Assign Assign

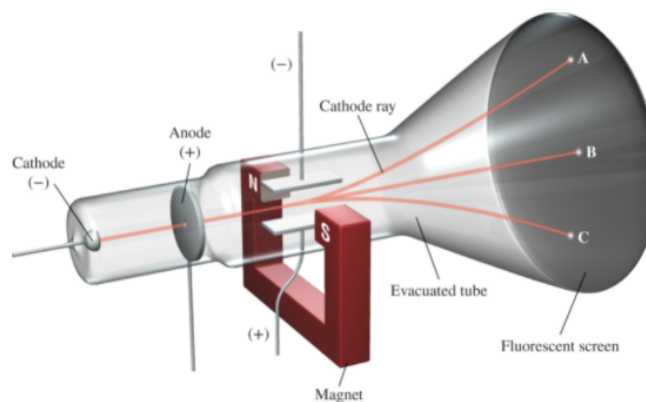
35 of 323

## 2.2 The Structure of the Atom

On the basis of Dalton's atomic theory, we can define an **atom** as the basic unit of an element that can enter into chemical combination. Dalton imagined an atom that was both extremely small and indivisible. However, a series of investigations that began in the 1850s and extended into the twentieth century clearly demonstrated that atoms actually possess internal structure; that is, they are made up of even smaller particles, which are called **subatomic particles**. This research led to the discovery of three such particles—**electrons, protons, and neutrons**.

### The Electron

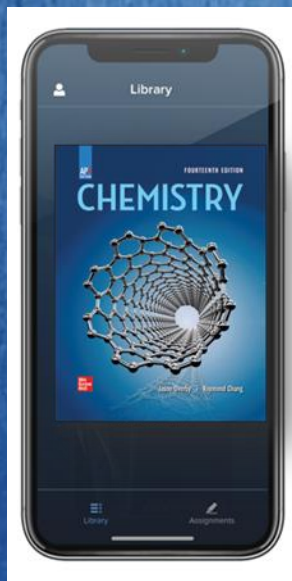
In the 1890s, many scientists became caught up in the study of **radiation**, the emission and transmission of energy through space in the form of waves. Information gained from this research contributed greatly to our understanding of atomic structure. One device used to investigate this phenomenon was a cathode ray tube, the forerunner of the television tube (Figure 2.3). It is a glass tube from which most of the air has been evacuated. When the two metal plates are connected to a high-voltage source, the negatively charged plate, called the **cathode**, emits an invisible ray. The cathode ray is drawn to the positively charged plate, called the **anode**, where it passes through a hole and continues traveling to the other end of the tube. When the ray strikes the specially coated surface, it produces a strong fluorescence, or bright light.



**Figure 2.3** A cathode ray tube with an electric field perpendicular to the direction of the cathode rays and an external magnetic field. The symbols N and S denote the north and south poles of the magnet. The cathode rays will strike the end of the tube at A in the presence of a magnetic field, at C in the presence of an electric field, and at B when there are no external fields present or when the effects of the

# McGraw Hill K-12 Portal Mobile App

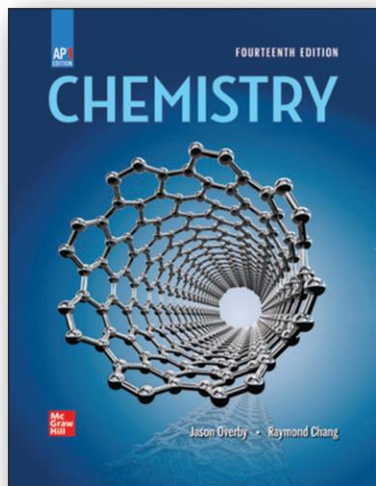
Anytime –  
No Internet  
Connection Needed!



Phone, iPad, Chromebook,  
or Tablet







# Adaptive SmartBook

4 of 71 Concepts completed

### Multiple Select Question

Select all that apply

Which of the following **molecular compounds** are primarily in the gas phase at 25°C and 1 atm?

- ☐ Ammonia
- ☐ Hydrogen chloride
- ☐ Nitrogen dioxide
- ☐ Silicon dioxide
- ☐ Water

Need help? Review these concept resources.

Read About the Concept

Rate your confidence to submit your answer. High Medium Low

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Video: Cathode Ray Tube

Highlighted content adapts as students work through the practice sets.

4 of 71 Concepts completed

Your Answer correct

When investigating gas behavior, we define normal atmospheric conditions as a temperature of 25 °C and a pressure of 1 atm.

Blank 1: 25  
Blank 2: 1 or one

Correct Answer

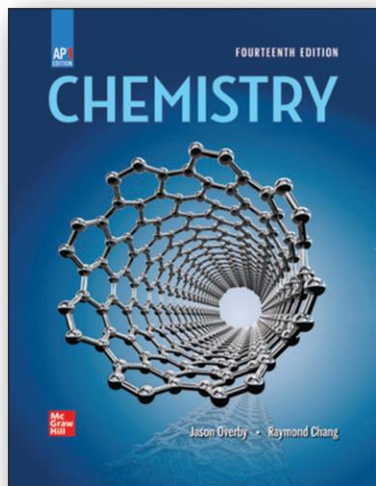
Blank 1: 25  
Blank 2: 1 or one

Next Question

Reading

Practice sets with instant feedback measure understanding and personalize the learning path based on student responses.





## Adaptive SmartBook

### Model 1: Flipped

SmartBook is  
used to  
preview  
content

### Model 2: Homework

SmartBook  
Is assigned as  
reinforcement

### Model 3: Review

SmartBook is  
assigned to  
review as a  
study tool

### Model 4: Self-Pacing

SmartBook is  
assigned as a  
tool to support  
self-pacing

# Virtual Labs

OSMOSIS • MOVEMENT OF WATER ACROSS A SELECTIVELY PERMEABLE MEMBRANE

INTRODUCTION

LABORATORY SIMULATION



Question



Why is this called a selectively permeable membrane?

- ☒ Because it allows small molecules, such as water, to pass through but not larger molecules, such as those in corn syrup.
- ☐ Because it allows any molecule to selectively choose what side of the membrane to move toward.

Correct. The membrane has holes only large enough to allow water to freely pass back and forth

Continue

PHASE 5:

Save Lab Data

Relevant Lab Data will be available if you return to this laboratory simulation. It can also be saved for personal reference.

Print or save pdf

Windows 10 and OS X both have native "print to pdf" capabilities. Implementation differs slightly by browser.



CONGRATULATIONS

You have finished this lab and it has been automatically submitted.



LAB COMPLETE



METHODS



RESET



MY NOTES



LAB DATA



SHOW LABELS

PHASES

5

# ALEKS Chemistry

Class Code: XXXXX-XXXXX CLASS TOOLS

	Progress ⓘ	Remaining ⓘ	Ready to Learn ⓘ	Attempted, Not Yet Learned ⓘ
<b>Atomic Structure (Progress 97%)</b>				
Identifying the parts of an atom	100%	0%	0%	0%
Counting protons and electrons in atoms and atomic ions	100%	0%	0%	0%
Finding isoelectronic atoms	100%	0%	0%	0%
Predicting the ions formed by common main-group elements	100%	0%	0%	0%
Isotopes	100%	0%	0%	0%
Finding atomic mass from isotope mass and natural abundance				
Finding isotope mass or natural abundance from atomic mass				

6 students out of 32 (19%) have **Not Learned** this topic.

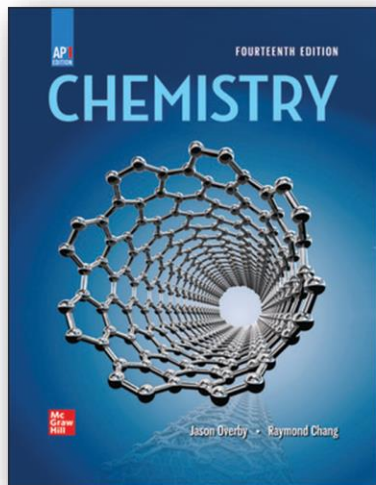
Anderson, Karen P.  
Davis, Bill B.  
Mendes, Karen A.  
Velasquez, Herbert A.  
Waltham, Cindy A.  
Young, Charles K.

Counting valence electrons in a neutral atom

## Elements, Compounds, and Mixtures (Progress 97%)

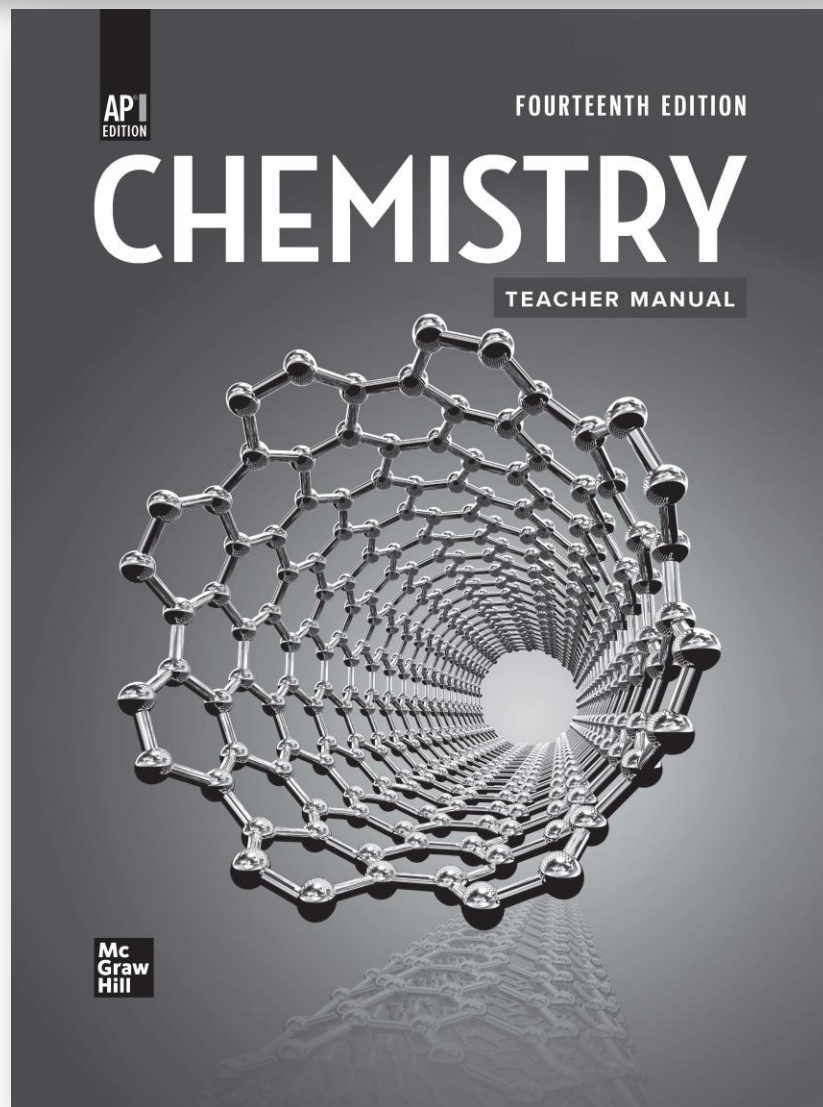
- Distinguishing elements and compounds
- Distinguishing compounds and mixtures
- Counting the number of atoms in a formula unit



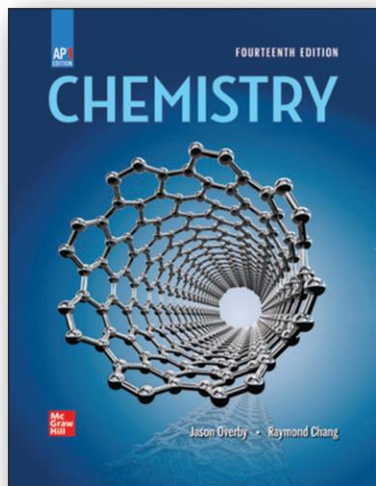


## Unmatched Instructional Support

- In print & online
- Classroom activities
- Pacing guides
- Lab activities
- Directives for using the AP Chemistry Lab Manual







# Unmatched Instructional Support

- AP Teacher Manual & Solutions Manual
- AP Assessment & Practice Exams
- Editable Test Banks
- PowerPoints and Lecture Tools
- Real-time Reports
- Searchable Resource Library

Chang, Chemistry, AP® Edition

Course Resources

Search Chang, Chemistry, AP® Edition

380 Results (limited to the current course)

Refine results

- Course Location
- Refine more...
- Browse Standards
- Resource Type

1. eBook Chapter 1

2. SmartBook Chapter 1

3. AP Chemistry Ch. 1 Test

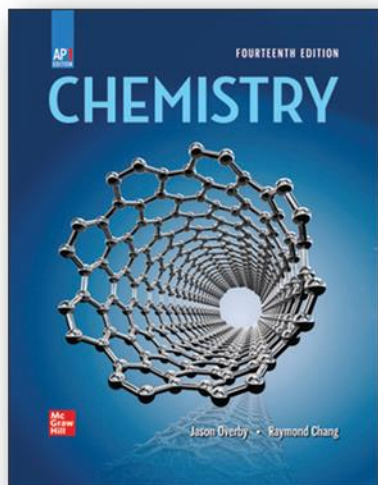
4. Chapter 1 Chemistry Content Review Assessment

5. Chapter 1 Chemistry Interactive Question Bank

6. PowerPoint Presentation

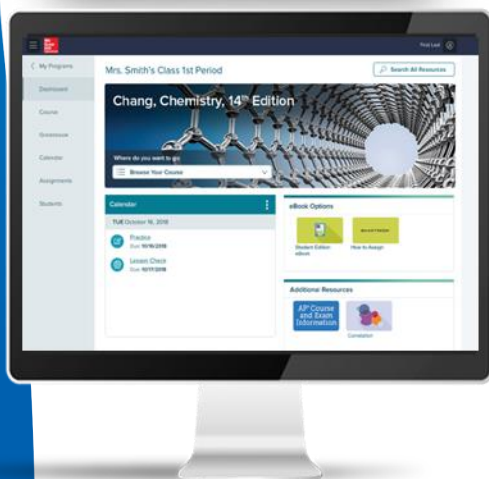
7. Slide 10 of 90

64%

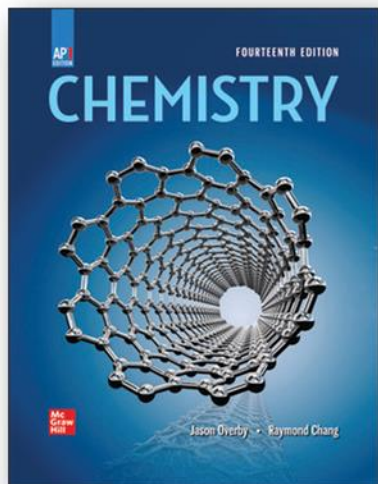


# Digital DEMO

# LET'S GO LIVE



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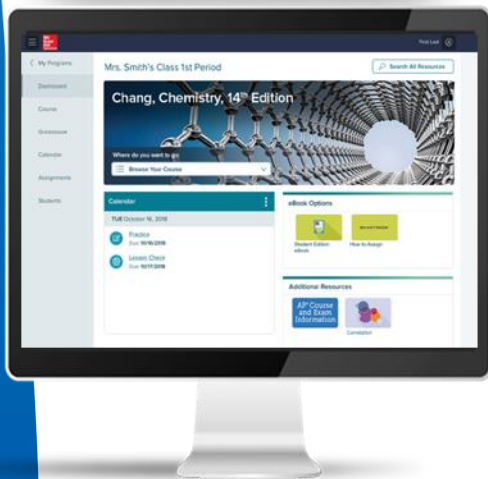


Digital DEMO

[my.mheducation.com](https://my.mheducation.com)

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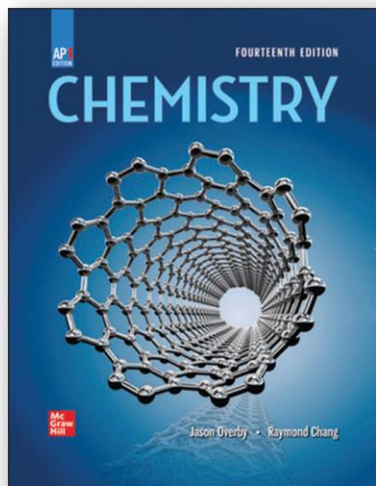
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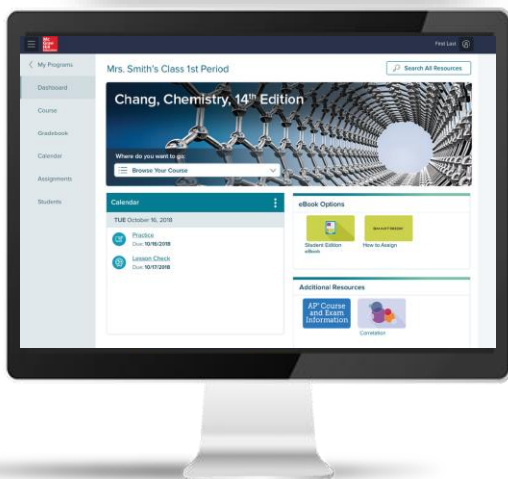


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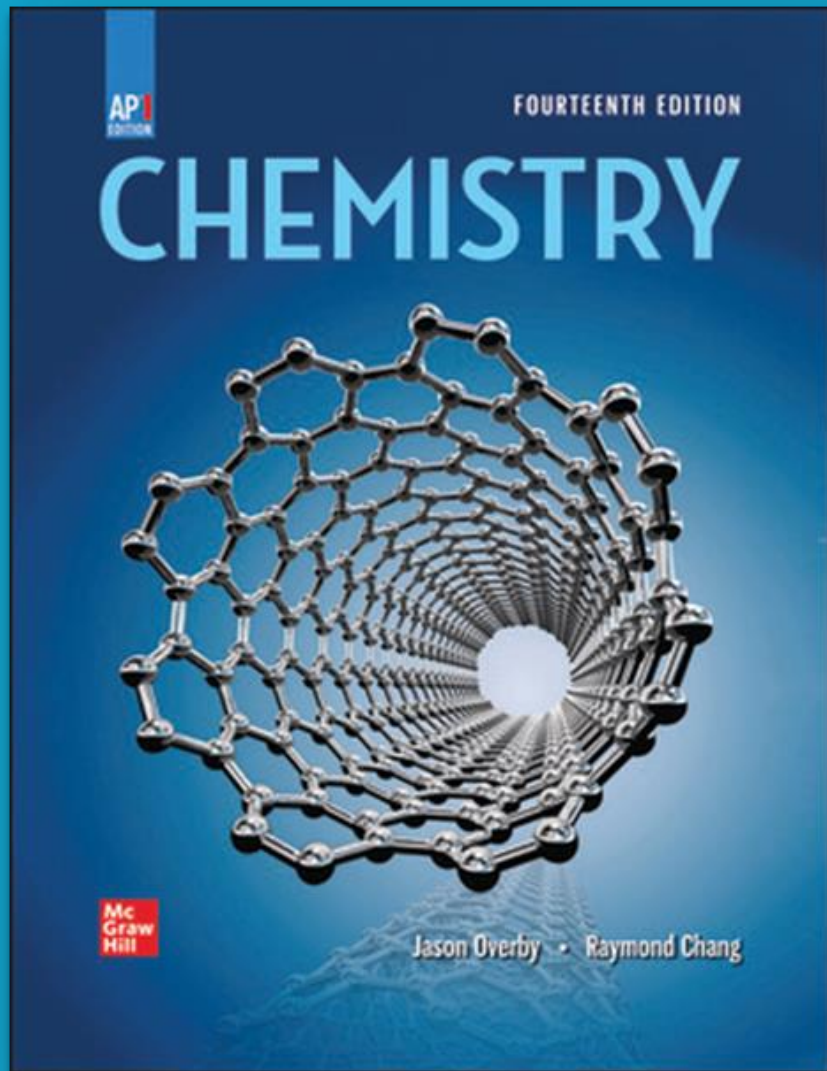


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