BROOKDALE COMMUNITY COLLEGE

CHEM 101 - GENERAL CHEMISTRY I

5.0 CREDITS

COURSE SYLLABUS
Course: CHEM-101  
Title: General Chemistry I

Institute: STEM  
Department: Chemistry

Course Description: The student will investigate the fundamental concepts of chemistry from a theoretical approach and participate in a laboratory program that demonstrates this theory. The subjects covered include atomic structure; chemical bonding, acids and bases, gases, solids and liquids and properties of solutions. The course content is designed for the science major who wishes to transfer to a four year institution.

Prerequisites: HS Chemistry or a grade of “C” or higher in CHEM 100 or equivalent, and a grade of “C” or higher in MATH 151.

Credits: 5  
Lecture Hours: 4  
Lab/Studio Hours: 3

REQUIRED TEXTBOOK/MATERIALS:


Laboratory Materials:
- Face-to-Face Students Only:
  - Lab Manual
  - Safety Goggles: New Jersey state law requires that all students wear appropriate splash and impact proof safety goggles while performing laboratory experiments. They are available at the College Store
  - Laboratory Coat: Available at the College Store
  - Calculator: Any scientific or graphing calculator will suffice

- Online Students Only:
  - Laboratory Kit - students are required to purchase a laboratory kit with an approximate cost of $200 plus shipping. No separate laboratory manual, goggles, nor lab coat need to be purchased.
    - http://www.esciencelabs.com/student

Additional Time Requirements:
For information on Brookdale’s policy on credit hour requirements and outside class student work refer to Academic Credit Hour Policy.
**CORE COMPETENCIES**

The following objectives of the Scientific Perspective, the Mathematical Skills Competency, and the Critical Thinking, Problem Solving Competency are taught in this course.

Students will:

1.1 Identify a problem and analyze it
1.2 Recognize and construct logical forms of argumentation

1.1 Be able to analyze, discuss and use quantitative information
1.2 Be able to apply algebraic and/or geometric techniques to analyze and solve mathematical problems
1.3 Use appropriate problem solving technologies

5.1 Develop appropriate skills in observation and experimentation to solve problems
5.2 Be able to analyze and interpret scientific data
5.3 Be able to evaluate and apply appropriate technology

The course tests, quizzes, labs, and other assignments are used to assess student attainment of these competency objectives within the context of the course curriculum.

In addition, this course reinforces objective 1.1 of the Communication Skills competency that states the student will “communicate information and ideas clearly and effectively in written form.” Students are required to write, using correct English, Mathematical and Chemical symbols, responses to lab and test questions requiring explanations, comparisons, and/or interpretation of results.

**COURSE LEARNING OUTCOMES:**

Upon completion of this course, students will be able to:

- Utilize critical thinking skills to learn fundamental chemical concepts from inorganic chemistry.
- Use the scientific method to perform chemistry-based problem-solving.
- Reinforcement of chemical concepts will be made as hands-on skills are developed in the laboratory program.
- Identify unknown compounds based on observed physical properties
- Describe how chemical reactions proceed
- Run successful titration experiments
- Analyze atomic spectra
**GRADING STANDARD:**

- **A** = 92 - 100%
- **A-** = 89 - 91%
- **B+** = 86 - 88%
- **B** = 82 - 85%
- **B-** = 79 - 81%
- **C+** = 76 - 78%
- **C** = 70 - 75%
- **D** = 65 - 69%
- **F** = <65%

Unit examination results are reported as the grade assigned by the faculty calculated to the first decimal place. These grades are weighed according to course grading policy. In calculating the course grade, 0.5 will round up to the next numerical grade and 0.4 will round down to the next lower numerical grade.

**COURSE CONTENT:**

Unit 1: Introduction; Chemistry: The Study of Change; Atoms, Molecules, and Ions; Mass Relationships in Chemical reactions

Unit 2: Reactions in Aqueous Solutions; Quantum Theory and the Electronic Structure of Atoms; Periodic Relationships Among the Elements

Unit 3: Chemical Bonding: Basic Concepts; Chemical Bonding II: Molecular Geometry and Hybridization of Atomic Orbitals

Unit 4: Gases; Intermolecular Forces and Liquids and Solids; Physical Properties of Solutions

**DEPARTMENT POLICIES:**

1. Students must attend their regularly scheduled weekly laboratory section.
2. Students are not allowed to attend any other lab section for any reason.
3. Students must pass (65% or better) both the lecture and the laboratory portion of the course in the same semester or they will fail the course.

**COLLEGE POLICIES:**

For information regarding:
- Brookdale’s Academic Integrity Code
- Student Conduct Code
- Student Grade Appeal Process

Please refer to the [BCC Student Handbook and BCC Student Catalog](#)
NOTIFICATION FOR STUDENTS WITH DISABILITIES:

Brookdale Community College offers reasonable accommodations and/or services to persons with disabilities. Students with disabilities who wish to self-identify must contact the Disabilities Services Office at 732-224-2730 (voice) or 732-842-4211 (TTY) to provide appropriate documentation of the disability, and request specific accommodations or services. If a student qualifies, reasonable accommodations and/or services, which are appropriate for the college level and are recommended in the documentation, can be approved.

ADDITIONAL SUPPORT/LABS:

Instructional Assistants are available for help for lab and lecture. The times of availability are posted at the Instructional Assistants’ office (MAS-031).

WEBSITE:  https://www.brookdalecc.edu/stem-institute/chemistry/
CHAPTERS: 1, 2, 3

NAME OF UNIT: Introduction, Mathematical Operations, Elements and Compound Composition, and a Study of Aqueous Reactions

UNIT OBJECTIVE: To acquaint the student with the mathematics necessary to pursue the subject matter of chemistry. To review basic chemical concepts and calculations covered in the prerequisite introductory chemistry course.

Learning Objectives

1. Understand the science of chemistry.
2. Distinguish between elements, compounds, and mixtures. Describe methods of mixture separation.
3. Distinguish between physical and chemical properties/changes.
4. Distinguish between the three states of matter.
5. Describe the importance of the scientific method.
6. List the common SI units and metric prefixes and their meanings.
7. Convert SI and non-SI units using dimensional analysis.
8. Determine the number of significant figures from measurements and their role in measurement precision.
9. Convert measurement values to scientific notation.

Recommended Learning Experiences

READ: 1.1
READ: 1.2, 1.3
DO: 1.1-4, 8-9, 14, 17-22
READ: 1.5
DO: 1.10-13
READ: 1.6
DO: 1.10-13
READ: 1.7
DO: 1.29-34
READ: 1.8, Appendix 2
MEMORIZE: Tables 1.1, 1.2
DO: 1.35
READ: 1.9, Appendix 2
DO: 1.37-52
READ: 1.10 p. 22-7
DO: 1.65-72
READ: Appendix 1
<table>
<thead>
<tr>
<th>Learning Objectives</th>
<th>Recommended Learning Experiences</th>
</tr>
</thead>
<tbody>
<tr>
<td>10. Perform calculations involving density.</td>
<td>READ: 1.5</td>
</tr>
<tr>
<td></td>
<td>DO: 1.53-60</td>
</tr>
<tr>
<td>11. Convert temperatures among Fahrenheit, Celsius, and Kelvin scales.</td>
<td>READ: 1.11 p. 32-4</td>
</tr>
<tr>
<td></td>
<td>DO: 1.77-88</td>
</tr>
<tr>
<td>12. Describe the contribution of each of the following to our understanding of the</td>
<td>READ: 2.2</td>
</tr>
<tr>
<td>atom: Dalton, Thomson, Millikan, Rontgen, Becquerel, Curie, Rutherford, and Chadwick.</td>
<td>DO: 2.11-14</td>
</tr>
<tr>
<td>13. Give the approximate size, relative mass and charge of an atom, a proton,</td>
<td>READ: 2.2</td>
</tr>
<tr>
<td>neutron, and an electron</td>
<td>STUDY: Table 2.1</td>
</tr>
<tr>
<td>14. Describe the composition of the atom in terms of protons, neutrons, and</td>
<td>READ: 2.3</td>
</tr>
<tr>
<td>electrons. Know their relationship to atomic number, mass number, and isotopes.</td>
<td>DO: 2.21-24</td>
</tr>
<tr>
<td>15. Relate atomic mass to the abundance and mass of the isotopes.</td>
<td>READ: 2.4</td>
</tr>
<tr>
<td></td>
<td>DO: 2.15-18, 25-30</td>
</tr>
<tr>
<td>16. Understand the arrangement of elements and the parts of the periodic table.</td>
<td>READ: 2.5</td>
</tr>
<tr>
<td>and use the table to classify elements as metals, nonmetals or metalloids.</td>
<td>DO: 2.5-9, 31-34</td>
</tr>
<tr>
<td>17. Describe the two types of compounds and distinguish between empirical formulas</td>
<td>READ: 2.6</td>
</tr>
<tr>
<td>and molecular formulas</td>
<td>DO: 2.10, 47-54, 57-62</td>
</tr>
<tr>
<td>18. Determine the charge a particular atom will have when it becomes an ion (an</td>
<td>READ: 2.6</td>
</tr>
<tr>
<td>anion or cation). State the numbers of protons, neutrons, and electrons it will</td>
<td>DO: 2.55-56</td>
</tr>
</tbody>
</table>
19. Determine the formula of an ionic compound based on ion charges determined from the periodic table.

20. Write the name of an inorganic compound given its chemical formula and perform the reverse operation. Memorize the name, charge, and formula of each of the polyatomic ions in Table 2.3

21. Identify substances as acids and bases. Distinguish between them.

22. Define the mole. Convert between numbers of moles, mass in grams and numbers of atoms or molecules using molar mass and Avogadro’s number

23. Balance chemical equations.

24. Use a balanced equation to calculate amounts of reactants and products with stoichiometry.

25. Calculate the percent composition and empirical formulas of compounds.

26. Determine the molecular formula of compounds from empirical formulas experimentally.

27. Describe the importance of the mass spectrometer in determining percent composition and empirical formulas.
<table>
<thead>
<tr>
<th>Learning Objectives</th>
<th>Recommended Learning Experiences</th>
</tr>
</thead>
</table>
| 28. Solve problems involving limiting and excess reagents. | READ: 3.9  
DO: 3.2, 4, 105, 109-116 |
| 29. Calculate percent yield using a balanced chemical equation. | READ: 3.9  
DO: 3.3, 9, 106-108, 117-118 |
**CHAPTERS:** 4, 7.1-7.8

**NAME OF UNIT:** Aqueous Solutions, Quantum Theory and the Electronic Structure of Atoms

**UNIT OBJECTIVE:** To study reactions in aqueous solution. To study the quantum theory and its relationship to the structure of atoms.

<table>
<thead>
<tr>
<th>Learning Objectives</th>
<th>Recommended Learning Experiences</th>
</tr>
</thead>
</table>
| 1. Calculate the molar concentration of compounds or ions. | **READ:** 4.2  
**DO:** 4.9-28 |
| 2. Describe how to dilute a solution and solve dilution problems | **READ:** 4.3  
**DO:** 4.29-36 |
| 3. Classify compounds as strong electrolytes, weak electrolytes and non-electrolytes, and distinguish between them. | **READ:** 4.4  
**DO:** 4.2, 4-5, 39, 44, 45-48 |
| 4. Write balanced molecular equations, balanced ionic equations, and balanced net ionic equations. | **READ:** 4.5  
**DO:** 4.57-62, |
| 5. Classify compounds as strong or weak acids, strong or weak bases, or salts. Write balanced chemical equations for the neutralization of an acid and a base. | **READ:** 4.5  
**MEMORIZE:** Table 4.3  
**DO:** 4.1, 3, 49-55 |
| 6. Describe the analytical method of titration and solve titration problems. | **READ:** 4.6  
**DO:** 4.63-68 |
| 7. Solve problems involving precipitation and gravimetric analysis. | **READ:** 4.7  
**MEMORIZE:** Table 4.4  
**DO:** 4.69, 4.75-83 |
<table>
<thead>
<tr>
<th>Learning Objectives</th>
<th>Recommended Learning Experiences</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Define and give examples of: oxidation, reduction, oxidizing agent, reducing agent, oxidation number and half reaction.</td>
<td>READ: 4.9</td>
</tr>
<tr>
<td>9. Calculate the oxidation number of each element in a compound.</td>
<td>READ: 4.9, DO: 4.93, 4.99-100, 105-106, 111a, 112a</td>
</tr>
<tr>
<td>11. Use the equations $c = \lambda$ and $E = hv$ to describe the wave properties of light.</td>
<td>READ: 7.2-3, DO: 7.9, 15-32, 36</td>
</tr>
<tr>
<td>12. Explain Planck’s quantum theory and relate it to Einstein’s explanation of the photoelectric effect.</td>
<td>READ: 7.3, DO: 7.33-35, 37-8, 43-44</td>
</tr>
<tr>
<td>13. Explain the origin of spectra and relate it to the quantum theory and the Bohr model of the atom</td>
<td>READ: 7.4, DO: 7.45</td>
</tr>
<tr>
<td>14. Calculate the energy differences between any two allowed energy states (transitions) of the electron in hydrogen.</td>
<td>READ: 7.4, DO: 7.6, 47-60</td>
</tr>
<tr>
<td>15. Calculate the wavelength of a particle from its mass and velocity (De Broglie’s equation).</td>
<td>READ: 7.5, DO: 7.61-62, 65-68</td>
</tr>
<tr>
<td>16. Describe Heisenberg’s uncertainty principle and wave-particle duality</td>
<td>READ: 7.5</td>
</tr>
<tr>
<td>17. Describe the quantum numbers $n$, $l$, $m_l$ and $m_s$, and their relationship to Schrödinger’s equation. Predict possible permutations of quantum numbers. Describe the importance of the Pauli Exclusion Principle</td>
<td>READ: 7.6, DO: 7.73-84</td>
</tr>
<tr>
<td>18. Describe the shapes of the s, p, and d orbitals.</td>
<td>READ: 7.7, DO:</td>
</tr>
<tr>
<td>Learning Objectives</td>
<td>Recommended Learning Experiences</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>19. Explain the concepts of orbital, electron density, probability and $\Psi^2$</td>
<td>READ: 7.5</td>
</tr>
<tr>
<td>as used in the quantum theory.</td>
<td></td>
</tr>
<tr>
<td>20. Write the orbital box diagram and the electron configuration for any atom.</td>
<td>READ: 7.8</td>
</tr>
<tr>
<td>Predict if an atom is paramagnetic or diamagnetic</td>
<td>DO: 7.1, 7.8, 85-86, 89-112</td>
</tr>
</tbody>
</table>
CHAPTERS: 7.8-12, 8, 9

NAME OF UNIT: Periodic Relationships Among Elements, Bonding, and Geometry of Molecules

UNIT OBJECTIVE: To study the relationship of chemical properties based on elements’ positions on the periodic table and bonding theories, and to determine the shapes of molecules

### Learning Objectives

1. Describe effective nuclear charge and its impact on the valence electrons
   
   **Recommended Learning Experiences**
   
   **READ** 7.8

2. Explain the development of the Periodic Table and how electron configurations relate to its arrangement. Use the Periodic Table to predict charges of monoatomic ions.
   
   **Recommended Learning Experiences**
   
   **READ** 7.8-9

3. Explain the periodic nature of atomic radius, ionic radius, and metallic and nonmetallic behaviors.
   
   **Recommended Learning Experiences**
   
   **READ**: 7.10
   **DO**: 7.113-116

4. Describe the periodic trends in ionization energy and electron affinity.
   
   **Recommended Learning Experiences**
   
   **READ**: 7.11-12
   **DO**: 7.117-126

5. Determine the number of valence electrons for any atom and write its Lewis symbol.
   
   **Recommended Learning Experiences**
   
   **READ**: 8.2
   **STUDY**: Figure 8.2
   **DO**: 8.1-2, 19-22, 27-28

6. Write Lewis structures for molecules and ions containing covalent bonds.
   
   **Recommended Learning Experiences**
   
   **READ**: 8.2
   **DO**: 8.14, 16, 26, 35-46
7. Predict on the basis of the Periodic Table the probable formulas of ionic substances formed between common metals and of nonmetals. READ: 8.2 DO: 8.3-4, 29-34

8. Be able to write Lewis structures for molecules that do not obey the octet rule. READ: 8.6 DO: 8.93-105, 107-110, 113


10. Calculate formal charges on atoms in Lewis structures. READ: 8.5 DO: 8.17, 81-92

11. Use electronegativity values to predict relative polarities of bonds. READ: 8.3 STUDY: Table 8.6 DO: 8.6-9, 12-13, 47-52, 57-66

12. Describe a covalent bond in terms of Lewis structures and describe the trend in bond length and bond stability. READ: 8.7 DO: 8.18, 115-134

13. Relate the number of electron pairs in the valence shell of an atom in a molecule to their geometrical arrangement around the atom. READ: 9.2


15. Predict whether a molecule has a dipole moment from its molecular geometry and electronegativities. READ: 9.3 DO: 9.1-2, 41-52

16. Explain the concept of hybridization and its relationship to geometrical structure using valence bond theory. READ: 9.4 DO:

17. Assign hybrid orbitals to an atom knowing the number and geometrical arrangement of the atoms to which it is bonded. READ: 9.4 STUDY: Table 9.3 DO:
### Learning Objectives

18. Formulate the bonding in a molecule in terms of bond overlap, sigma bonds and pi bonds.  
   **Recommended Learning Experiences**
   - **READ:** 9.4
   - **DO:** 9.4, 91-92

19. Describe molecular orbital theory in terms of atomic orbital overlap.  
   **READ:** 9.7

20. Explain the relationship between bonding and antibonding molecular orbitals.  
   **READ:** 9.7

21. Construct energy level diagrams for the molecular orbitals of diatomic molecules or ions built from elements of the first or second period and predict the bond order, stability of the molecule, type of magnetism, electron configuration of the molecule, and relative bond length.  
   **READ:** 9.7
   **DO:** 9.5-6, 95, 101-112

22. Use the Molecular Orbital Theory to explain delocalization.  
   **READ:** 9.8
NAME OF UNIT: Gases, Liquids, Solutions, and Solids

UNIT OBJECTIVE: To study the three states of matter. To study the physical properties of solutions.

<table>
<thead>
<tr>
<th>Learning Objectives</th>
<th>Recommended Learning Experiences</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Recognize substances that are gases.</td>
<td>READ: 6.1</td>
</tr>
<tr>
<td></td>
<td>DO: 6.2</td>
</tr>
<tr>
<td>2. Define the units of pressure: atm, mmHg, Torr, and Pa. Be able to interconvert them. Describe how a barometer works.</td>
<td>READ: 6.2</td>
</tr>
<tr>
<td></td>
<td>DO: 6.1, 23-42</td>
</tr>
<tr>
<td></td>
<td>DO: 6.3-12, 43-70</td>
</tr>
<tr>
<td>4. Solve problems using the Ideal Gas Law. Use the Ideal Gas Law in problems involving molar mass, and density.</td>
<td>READ: 6.4 &amp; 6.6</td>
</tr>
<tr>
<td></td>
<td>DO: 6.71-80, 87-96</td>
</tr>
<tr>
<td>5. Use the Ideal Gas Law to do calculations from balanced chemical equations (using stoichiometry).</td>
<td>READ: 6.5</td>
</tr>
<tr>
<td></td>
<td>DO: 6.81-86</td>
</tr>
<tr>
<td>6. Calculate the partial pressure of any gas in a mixture using Dalton’s Law. Calculate the mole fraction of the gas.</td>
<td>READ: 6.7</td>
</tr>
<tr>
<td></td>
<td>DO: 6.13-14, 97-116</td>
</tr>
<tr>
<td>7. Explain the assumptions on which the Kinetic Molecular Theory is based.</td>
<td>READ: 6.8</td>
</tr>
<tr>
<td>Learning Objectives</td>
<td>Recommended Learning Experiences</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------</td>
</tr>
</tbody>
</table>
| 8. Describe how the distribution of speeds and the average speed of gas molecules changes with temperature. | **READ:** 6.8  
**DO:** 6.15-16 |
| 9. Compare and contrast effusion and diffusion and their relationship with the root mean square of gases. Calculate the relative speeds of molecules using Graham’s Law of Effusion. | **READ:** 6.8  
**DO:** 6.17-21, 117-140 |
| 10. Describe the deviation of real gases from ideal behavior and give reasons for it. Make corrections using the van der Waals equation. | **READ:** 6.9  
**DO:** 6.141-148 |
| 11. Describe the various types of intermolecular attractive forces and state the kinds of intermolecular forces expected for a substance given its molecular structure. | **READ:** 10.1-3  
**DO:** 10.1, 9-14, 19-22, 29, 31-34 |
| 12. Rationalize the physical states and solubilities of substances in various solvents in terms of their molecular structures and intermolecular forces. | **READ:** 10.4  
**DO:** 10.2-4, 15-18, 23-24, 27-28, 30, 35-45, 47-50 |
| 13. Describe the effects of temperature and pressure on solubility of gases in water. | **READ:** 10.5  
**DO:** 10.46, 10.51-62 |
| 14. Explain the way in which the vapor pressure of a substance changes with intermolecular forces and temperature. | **READ:** 10.6  
**OMIT:** Clausius-Clapeyron Equation  
**DO:** 10.63-69 |
| 15. Describe the relationship between the pressure on the surface of a liquid and the boiling point of that liquid. | **READ:** 10.6  
**DO:** 10.6 |
<table>
<thead>
<tr>
<th>Learning Objectives</th>
<th>Recommended Learning Experiences</th>
</tr>
</thead>
<tbody>
<tr>
<td>16. Know the terms associated with each kind of phase change.</td>
<td>READ: 10.7</td>
</tr>
<tr>
<td></td>
<td>DO: 10.71</td>
</tr>
<tr>
<td>17. Define critical temperature and pressure. Draw a phase diagram of a substance given appropriate data, and use a phase diagram to predict what phases are present at any given temperature and pressures.</td>
<td>READ: 10.7</td>
</tr>
<tr>
<td></td>
<td>DO: 10.7, 70-90</td>
</tr>
<tr>
<td>18. Explain the meaning of the terms viscosity and surface tension, and account for the variations of these properties in terms of intermolecular forces and temperature.</td>
<td>READ: 10.8</td>
</tr>
<tr>
<td></td>
<td>DO: 10.91-100</td>
</tr>
<tr>
<td>19. Describe the energy changes that occur in the solution process in terms of solute-solute, solvent-solvent, and solute-solvent attractive forces; describe the role of disorder in the solution process.</td>
<td>READ: 11.1-2</td>
</tr>
<tr>
<td></td>
<td>OMIT: Born-Haber Cycle</td>
</tr>
<tr>
<td></td>
<td>DO: 11.1-3, 11.9-12</td>
</tr>
<tr>
<td>20. Define various concentration units: percent by mass, mole fraction, molarity, and molality.</td>
<td>READ: 4.2, 6.7, 11.5</td>
</tr>
<tr>
<td></td>
<td>DO: 4.12-27, 11.48-49, 63-68</td>
</tr>
<tr>
<td>21. Describe the impact of adding a nonvolatile solute to a solvent on the solvent’s vapor pressure. Calculate using Raoult’s Law</td>
<td>READ: 11.3</td>
</tr>
<tr>
<td></td>
<td>DO: 11.29-33</td>
</tr>
<tr>
<td>Learning Objectives</td>
<td>Recommended Learning Experiences</td>
</tr>
<tr>
<td>---------------------</td>
<td>----------------------------------</td>
</tr>
</tbody>
</table>
| 22. Describe the effect of solute concentration on the boiling point, freezing point, and osmotic pressure of a solution. Calculate any of these properties given appropriate concentration data. Calculate any of these properties given appropriate concentration data. | **READ:** 11.5  
**DO:** 11.5-7, 47, 55-62, 69-89 |
| 23. Explain the difference in the change in colligative properties caused by electrolytes compared to nonelectrolytes. | **READ:** 11.5  
**DO:** 11.51-54, 90 |
| 24. Determine the concentration and molar mass of a nonvolatile nonelectrolyte from its effect on the colligative properties of a solution. | **READ:** 11.6  
**DO:** 11.91-94 |
| 25. Distinguish between crystalline and amorphous solids. | **READ:** 12.1  
**DO:** 12.1 |
| 26. Classify substances as to type of solid and predict the general properties of each. | **READ:** 12.1  
**STUDY:** Table 12.1 |
| 27. Determine the net contents of a cubic unit cell. Relate this information to density. | **READ:** 12.2  
**DO:** 12.2-7, 16-22 |
| 28. Describe packing patterns of equal size spheres. | **READ:** 12.2  
**DO:** 12.8 |