Pearson

Chapter Summary and Review

Key Learning Outcomes

Chapter Objectives	Assessment
Use Bragg's Law in X-Ray Diffraction Calculations (12.2)	• Example 12.1 For Practice 12.1 Exercises 27, 28
Calculate the Packing Efficiency of a Unit Cell (12.3)	• Example 12.2 For Practice 12.2 Exercises 31, 32
Relate Unit Cell Volume, Edge Length, and Atomic Radius (12.3)	• Example 12.3 For Practice 12.3 Exercises 33, 34, 35, 36
Relate Density to Crystal Structure (12.3)	• Example 12.4 For Practice 12.4 Exercises 33, 34, 35, 36, 37, 38
Classify Crystalline Solids (12.4)	• Example 12.5 For Practice 12.5 Exercises 39, 40, 41, 42, 43, 44, 49, 50, 53, 54

Key Terms

Section 12.1

graphene

Section 12.2

X-ray diffraction

Section 12.3

crystalline lattice
unit cell
simple cubic
coordination number
packing efficiency
body-centered cubic
face-centered cubic
hexagonal closest packing
cubic closest packing

Section 12.4

molecular solid
ionic solid
atomic solid
nonbonding atomic solid
metallic atomic solid
electron sea model
network covalent atomic solid

Section 12.6

allotrope
graphite
diamond
fullerenes
nanotubes
silicates
quartz
silica

Section 12.7

ceramics
clay
Portland cement
concrete
glass
vitreous silica (fused silica)
soda-lime glass
borosilicate glass (Pyrex®)
leaded glass

Section 12.8

band theory
valence band
conduction band
band gap
n-type semiconductor
p-type semiconductor
p-n junctions
diode

Section 12.9

polymer
monomer
addition polymer
dimer
copolymer
condensation polymer

Key Concepts

Crystalline Structures (12.2–12.3)

- X-ray crystallography uses the diffraction pattern of X-rays to determine the crystal structure of solids.
- The crystal lattice is represented by a unit cell, a structure that reproduces the entire lattice when repeated in three dimensions.
- Three basic cubic unit cells are the simple cubic, the body-centered cubic, and the face-centered cubic.
- Some crystal lattices can also be depicted as closest-packed structures, including the hexagonal closest-packing structure (not cubic) and the cubic closest-packing structure (which has a face-centered cubic unit cell).

Types of Crystalline Solids (12.4)

- The basic types of crystalline solids are molecular, ionic, and atomic solids. We divide atomic solids into three different types: nonbonding, metallic, and covalent.

Structure of Ionic Solids (12.5)

- Ionic solids have structures that accommodate both cations and anions.
- Common cubic structures for ionic compounds include the cesium chloride structure, the rock salt structure, the zinc blende structure, the fluorite structure, and the antifluorite structure.

Network Covalent Atomic Solids (12.6)

- Carbon forms the network covalent atomic solids graphite and diamond.
- SiO_2 forms the network covalent atomic solid quartz.

Ceramics, Cement, and Glass (12.7)

- Ceramics are inorganic nonmetallic solids that are prepared from powders typically mixed with water, formed into the desired shape, and then heated. Ceramic are usually hard, strong, nonconductive, and brittle.
- Cement is a powdered mixture consisting mostly of limestone ($CaCO_3$) and silica (SiO_2), with smaller amounts of other substances. When cement is mixed with water, it reacts to form a hard, stone-like substance.
- Glass is primarily amorphous (SiO_2) or silica. Silicate glass is transparent, impervious to water, and an outstanding material for making windows and drinking vessels.

Semiconductors and Band Theory (12.8)

- Band theory is a model for bonding in solids in which the atomic orbitals of the atoms are combined and delocalized over the entire crystal solid. In band theory, solids form energy bands that are occupied by electrons.
- In metals, the valence band (composed of bonding molecular orbitals) is continuous with the conduction band (composed of antibonding molecular orbitals).
- Semiconductors have a small energy gap—called the band gap—between the valence band and the conduction band.
- Semiconductors can be doped with small amounts of impurities to modify their conductivity.

Polymers and Plastics (12.9)

- Polymers are long, chainlike molecules that consist of repeating units called monomers. They can be natural or synthetic.
- Polyethylene is an addition polymer, a polymer formed without the elimination of any atoms.
- Condensation polymers, such as nylon, are formed by the elimination of small groups of atoms.

Key Equations and Relationships

Bragg's Law: Relationship between Light Wavelength λ, Angle of Reflection θ, and Distance (d) between the Atomic Layers (12.2)

$$n\lambda = 2d \sin\theta \, (n = \text{integer})$$