CHAPTER 12

STRUCTURES AND PROPERTIES OF CERAMICS

LEARNING OBJECTIVES

1. Make a distinction between *cations* and *anions*.
2. Cite two features of the component ions that determine the crystal structure of a ceramic material.
3. Sketch (or describe) unit cells for sodium chloride, cesium chloride, zinc blende, fluorite, and perovskite crystal structures.
4. Given the chemical formula for a ceramic compound, the ionic radii of its component ions, and, using Table 12.4, determine the crystal structure.
5. For a ceramic material which crystal structure may be generated from the stacking of close-packed planes of anions, given which type of interstitial positions (tetrahedral or octahedral) are occupied with cations, do the following:
   (a) specify what fraction of these sites are filled, and
   (b) note the occupied interstitial positions between two close-packed planes drawn as stacked one upon the other.
6. For an ionic compound having one of the crystal structures discussed in this chapter, be able to compute its density given the atomic weights of the constituent elements, the unit cell edge length, and Avogadro's number.
7. Given the unit cell for some ceramic crystal structure, be able to sketch the ionic/atomic packing of a specified crystallographic plane.
8. Draw and describe the basic structural unit for the silicate ceramics.
9. Schematically diagram the atomic structure of a silica glass.
10. Sketch (or describe) the following:
    (a) a unit cell for the diamond cubic crystal structure,

(b) the atomic structure of graphite,

(c) the structure of a C_{60} fullerene molecule, and

(d) the structure of a carbon nanotube.

11. Name and describe eight different ionic point defects that are found in ceramic compounds (including Schottky and Frenkel defects).

12. Define the term *electroneutrality*, and note what part it plays in the formation of ionic point defects in ceramic materials.

13. Define *stoichiometric*, and cite one example of a nonstoichiometric material.

14. Note two ways in which an ionic compound can be made to be nonstoichiometric.

15. (a) Given a substitutional impurity ion, determine whether or not it will render an ionic compound nonstoichiometric.

(b) If the host material does become nonstoichiometric, ascertain what kind(s) of defect(s) form, and how many form for every substitutional impurity ion.

16. Note three requirements that must be met in order for there to be significant solid solubility of one ionic compound in another.

17. Note one difference in diffusion mechanism for ionic ceramics and for metals.

18. Cite the differences in room temperature mechanical characteristics for metals and ceramics.

19. Briefly explain why there is normally significant scatter in the fracture strength for identical specimens of the same ceramic material.

20. Note the reason why ceramic materials are stronger in compression than in tension.

21. Give three reasons why the stress-strain characteristics of ceramic materials are determined using transverse bending tests rather than tensile tests.

22. Given the cross-sectional dimensions of a rectangular ceramic rod bent to fracture using a three-point loading technique, as well as the distance

between support points, and the fracture load, compute the flexural strength.

23. Given the radius of a cylindrical ceramic rod that is bent to fracture using a three-point loading technique, as well as the distance between support points, and the fracture load, compute the flexural strength.
24. Briefly describe the mechanism by which plastic deformation occurs for each of crystalline and noncrystalline ceramic materials.
25. On the basis of slip considerations, briefly explain why crystalline ceramic materials are so brittle.
26. Briefly define viscosity and cite the units in which it is expressed.
27. For a porous ceramic, do the following:
    (a) Given the modulus of elasticity for the nonporous material, compute E for a specified volume fraction of porosity.
    (b) Given values of the experimental σ_o and n constants, calculate the flexural strength at some given P.