(Multiple choice, 4 points)

1. Which of the following is a semiconductor?
   a. InI       c. K₃As       e. H₂S
   b. InI₃      d. InP        f. MgF₂

2. A wider band gap corresponds to a material that has the properties of a
   a. conductor  c. ceramic  e. semiconductor  g. metal
   b. Insulator  d. polymer  f. metal halide

3. Which of the following elements will act as semiconductors in their pure form.
   a. As       c. Ge        e. Sn        g. Si
   b. Al       d. C         f. O         h. a, c, d
   i. c, d, g

4. Which of the following elements, if doped into silicon would produce an n-type
   semiconductor.
   a. Ga       c. C         e. Na        g. e, f, d
   b. As       d. Al        f. Mg

5. Which of the following elements, if doped into silicon, would produce a p-type
   semiconductor?
   a. Ga       c. Ge        e. P         g. b, e, f
   b. As       d. C         f. Se        h. a and d
   i. c, d

6. Which kinds of materials have exhibited superconductivity?
   a. Acids    c. Metals     e. Liquid crystals  g. c and f
   b. Ceramics d. Polymers   f. b and d     h. a, b and c.

7. Of the following chemical forms, which are not commonly found in ceramics?
   a. silicates  c. nitrates      e. aluminates
   b. oxides     d. carbides      f. metals

8. Which of the following is not a biopolymer?
   a. protein     c. RNA        e. silicate (sand)
   b. polysaccharide   d. DNA     f. polyester  
   g. e and f       i. c, d and f
   h. e, f and b
9. Superconductivity means that:
   a. electrons move faster
   b. electrons move through a shorter path
   c. diamagnetic atoms become elongated
   d. electrons move without resistance
   e. A phase change occurred
   f. The molecular structure of the material was altered
   g. e and f
   h. d, e and f
   i. b, e and f
   j. a, b, d, e and f

10. Of the following which is not a polymer?
    a. cellulose  c. nylon   e. stainless steel  g. b, d and e
    b. starch  d. protein  f. d and e

11. Ceramics have the following advantages over metal parts:
    a. They are better conductors at room temperature
    b. They are less dense than metals
    c. They are less brittle than metals
    d. They are stronger than metals
    e. They are more resistant to corrosion than metals
    f. b and e
    g. a, b and e
    h. a, b, d and e

12. In the superconducting ceramic YBa$_2$Cu$_3$O$_7$, what is the average oxidation state of copper, assuming that Y and Ba are in their expected oxidation states?
    a. 1  c. 3  e. 2.666  g. 2.895  i. 2.5
    b. 2  d. 2.333  f. 3.222  h. 4  j. 3.2

13. Silicon has a face-centered cubic lattice with four silicon atoms in each cube-shaped unit cell. The unit cell has edges of 5.43 Å. How many Silicon atoms are in 2.5 cm$^3$ of silicon?
    a. $6.2 \times 10^{22}$  c. $3.1 \times 10^{22}$  e. $4.25 \times 10^{18}$  g. 10
    b. $6.2 \times 10^{24}$  d. $3.1 \times 10^{24}$  f. 4  h. 14

14. If phosphorous is doped into the above material to 1 ppm (part per million), the conductivity of the silicon increases by 1 million. How many milligrams of P are required?
    a. $3.2 \times 10^6$  c. $3.2 \times 10^4$  e. 30  g. $4 \times 10^8$
    b. $6.4 \times 10^6$  d. $3.2 \times 10^{16}$  f. $1.8 \times 10^6$  h. $3 \times 10^3$
15. Which of the following features of a molecule would be important for its use in liquid crystal displays
   a. Many sp\(^3\) hybridized centers
   b. An elongated shape
   c. A dipole moment
   d. A relatively rigid structure
   e. A reasonable conductivity
   f. Water solubility
   g. b and d
   h. b, c and d
   i. b, c, d and e
   j. all of the above

16. Making the particulate size of a material smaller can lead to:
   a. Widening the band gap of a semiconductor.
   b. Widening the band gap of a conductor
   c. Narrowing the band gap of a semiconductor
   d. Narrowing the band gap of a conductor
   e. Altering the color of a conductor
   f. Altering the color of a semiconductor
   g. Changing the florescence wavelength
   h. a, b, e and f
   i. a, f and g
   j. c,d,e and g

17. Give the orbital hybridization of the central atom in XeF\(_2\)
   a. sp\(^2\)
   b. sp\(^3\)
   c. sp\(^2\)
   d. sp\(^3\)
   e. sp\(^3\)d
   f. sp\(^3\)d\(^2\)
   g. sp\(^3\)d\(^3\)
   h. p
   i. s
   j. d

18. Which kinds of orbitals are involved in the bond between the C and O in carbon monoxide?
   a. sp
   b. sp\(^2\)
   c. sp\(^2\)
   d. sp\(^3\)
   e. sp\(^3\)d\(^3\)
   f. p
   g. s
   h. d
   i. a and f
   j. b and f
(essay/short answer, 9 points)
19. Draw a picture of a diode and explain briefly how it works and what it does.

See book chapter 12.

20. Draw the molecular orbitals for O\textsubscript{2} in order of energy and fill them with the appropriate number of electrons. Is O\textsubscript{2} diamagnetic or paramagnetic? Explain using your diagram.

See book, chapter 9. O\textsubscript{2} will have two unpaired electrons when orbitals are filled.

21. (10 points) 1,2-dichloro ethane exists as a single isomer, while 1,2 dichloro ethene exists as two separate isomers (isomers are molecules that have the same composition but different geometric structures). Give the hybridization about each carbon atom in the two molecules. Describe the orbitals that are involved in the carbon carbon bond in the two molecules, and give an explanation for the difference in isomer number for the two.

<table>
<thead>
<tr>
<th>Sp\textsubscript{3} hybridization</th>
<th>sp2 hybridization</th>
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<tbody>
<tr>
<td>No pi bonds</td>
<td>pi bonds from p orb. overlap</td>
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Isomerization from lack of rotation about C-C bond in dichloro-ethene.

1,2-dichloro ethane

1,2-dichloro ethene