LED Assessment

Name _____
Date _____ Hour ____

Matching

Match the word with the best definition.

____ 1. LED

____ 2. doping

____ 3. solid solution

____ 4. semiconductor

____ 5. band gap

____ 6. conduction band

____ 7. insulator

____ 8. metal

____ 9. valence band

____ 10. energy band

____ 11. orbital

____ 12. isoelectronic

____ 13. electronegativity

____ 14. biasing

a. the attraction of an atom for electrons
b. the highest energy filled band that lies at the bottom of the band gap
c. a type of material that is a poor conductor of electricity
d. applying a voltage, often done to alter electrical and optical output of a device
e. a material with a partially filled energy band
f. a semiconductor p-n junction that is optimized to release light of about the band gap energy when electrons fall from the conduction band to the valence band under forward bias
g. containing the same number of electrons
h. a homogeneous solid in which one type of atom (or ion) has been substituted for a similar atom (or ion) in a structure
i. the energy separation between the top of the valence band and the bottom of the conduction band
j. a region of the atom where electrons are most likely to be found when they have a particular energy
k. a collection of orbitals closely spaced in energy
l. a band that when partially occupied by mobile electrons, permits their net movement in a particular direction
m. process by which atoms in a semiconductor are replaced with other atoms having more or less valence electrons, which leads to an excess of mobile electrons or holes, respectively
n. a substance conducting only a slight electrical current at room temperature

Multiple Choice

Choose the best answer.

____ 15. An example of a solid that possesses the zinc blende structure is
a. NaCl
b. CsCl
c. GaAs
d. Zn

____ 16. Energies of the electrons *within any one isolated atom* exhibit all these characteristics **EXCEPT**
a. At most, only two electrons may occupy any one orbital.
b. Electrons within the same orbital must "spin" in opposite directions.
c. Electrons fill the lowest energy levels first.
d. Electrons occupy spaces in between energy levels.

____ 17. Although the alkaline earth metals have their s orbitals filled and the p orbitals empty, overlapping occurs because
a. a "bridge" exists between the two types of orbitals.
b. the lowest levels of the p band are lower in energy than the upper levels of the s band.
c. the highest levels of the p band are lower in energy than the upper levels of the s band.
d. the lowest levels of the p band are higher in energy then the upper levels of the s band.

____ 18. If a material has a band gap in the ultraviolet portion of the spectrum, it will appear
a. black
b. red
c. violet
d. colorless

____ 19. A semiconducting solid solution used in manufacturing an LED has the zinc blend structure and the chemical formula $Al_xGa_{0.35}As_yP_{0.80}$, where
a. x = 0.80 y = 0.35
b. x = 0.65 y = 0.20
c. x = 1.00 y = 0.00
d. x = 0.20 y = 0.65

____ 20. For electrical conductivity two conditions are necessary, namely
a. the presence of charged particles and their ability to move.
b. the presence of charged particles and their stability.
c. the presence of neutral atoms and their ability to move.
d. the presence of neutral atoms and their stability.

____ 21. As the size of atoms increase in a solid, the accompanying orbital overlaps
a. are increased, and the resulting energy gaps get larger.
b. are increased, and the resulting energy gaps get smaller.
c. are reduced, and the resulting energy gaps get larger.
d. are reduced, and the resulting energy gaps get smaller.

True/False

If the statement is true, write true on the line. If the statement is false, correct the underlined word and place that on the line.

_____ 22. Only electrons near the bottom of the filled orbitals of a band contribute to electrical conductivity.

_____ 23. LEDs last longer, are brighter, and are more efficient than incandescent lights.

_____ 24. Solids having atoms of comparable sizes and forming the zinc blende structure can be combined to form solid solutions.

_____ 25. Solid solutions can be formed in a few stoichiometries, which allows the "tuning" of band gap energies.

_____ 26. Elements having the zinc blende structure contain different numbers of valence electrons.

Problems

27. Suppose you want to create a red cutoff filter (of all the colors in the visible region of the spectrum, the filter will transmit only red light). What should the band gap be to make such a filter out of a semiconductor?

28. Sketch the band-structure diagrams for an insulator, a semiconductor, and a metal.

29. Name two solids with the zinc blende structure that are isoelectronic with α-Sn, and predict how their band gaps will compare to that of α-Sn.

30. Suggest a two-element (binary) compound that is isoelectronic with diamond; such a material might be expected to rival diamond in hardness.

31. Explain why $CdSnP_2$ has the same valence electron count as GaAs.

32. Which contain partially filled bands and why: Mg, Si, and NaCl?

33. Some LED materials can be prepared by combining Ga, In, As, and P in the zinc blende structure. If the formula of one such solid is $Ga_{0.4}In_xAs_yP_{0.7}$, what are x and y equal to, and how would you interpret this formula based on the zinc blende structure?