LED Review Questions

1. Consider two samples in the form of powders: sample A is a physical mixture comprising equal moles of pure Ge and pure Si; sample B is a solid solution of composition $Si_{0.5}Ge_{0.5}$. For which of the following measurements will the two samples appear identical?

   A. X-ray diffraction
   B. elemental analysis
   C. band gap energy measurement based on absorption of light
   D. none of the above

2. Both of the semiconductors GaAs and GaP have the zinc blende structure. From X-ray diffraction, one sample has a cubic unit cell size of 5.45 Angstroms and the other has a cubic unit cell size of 5.65 Angstroms.
   a) Which is which based on position in the periodic table?

   b) From the relationship between atomic spacing and the resulting diffraction spots, which sample, GaAs or GaP, would have given the larger diffraction pattern and why?

3. Is Ga or Al more electronegative? Considering only the electronegativity difference, would GaAs or AlAs have a larger band gap energy? Explain.

4. Considering only atomic radii, rank the following in order of increasing band gap energy: $GaP_{0.40}As_{0.60}$, $GaP_{0.65}As_{0.35}$, $GaP_{0.85}As_{0.15}$, $GaP_{1.00}As_{0.00}$

5. Considering only electronegativity, rank the following in order of increasing band gap energy: $Al_{0.35}Ga_{0.65}As$, $Al_{0.25}Ga_{0.75}As$, $Al_{0.15}Ga_{0.85}As$, $Al_{0.05}Ga_{0.95}As$

6. What usually happens to the bond distances of a material when it is cooled? Considering only bond distance, would a material's band gap be larger when warm or cold? Explain.

7. Some LED materials can be prepared by combining Ga, In, As, and P in the zinc blende structure. If the formula of the solid is $Ga_{0.45}In_xAs_{0.75}P_y$, what are x and y equal to, and how would you interpret this formula based on the zinc blende structure?

8. Give a brief explanation for the following:
   Why does squeezing some LED's (applying pressure to them) make their spectrum move to shorter wavelengths?

9. In a recent news clipping from *Science* magazine, a breakthrough in making blue LEDs was described. Samples of gallium nitride, GaN, can give blue emission. In our lab, the green LED was GaP. If both GaP and GaN are emitting at about their band gap energies, discuss why it is reasonable that GaN would emit in the blue part of the spectrum.

10. Predict what would happen to the emission spectrum of the GaN LED if it were run at low temperatures (e.g., a cold Madison day) and why.

11. GaN is described as being harder (more resistant to mechanical damage) than ZnSe, which is also being used to construct blue LEDs. Suggest a reason why GaN is harder.

12. Explain with a sketch why the emission of an LED can give an estimate of the band gap energy of the solid.

13. Two LEDs are excited with the same amount of electrical energy from a battery and emit the same number of photons. One of these LEDs is emitting green photons at around 500 nm; and the other is emitting red photons at around 700 nm. Which is doing a better job of converting the electrical energy into light energy and why (i.e., which is more energy efficient?)?

14. An InP LED is connected between electrodes. Does it matter which side of the p-n junction is connected to which electrode and, if so, how do you connect it to make it glow?

15. Suggest dopants that will substitute for In to make the p-type region of the LED and for P to make the n-type region. Explain your choices.

16. If a material has a band gap in the infrared portion of the spectrum, it will appear
    A. black.
    B. red.
    C. green.
    D. colorless.