Session #14: Homework Problems

Problem #1

(a) Determine the amount (in grams) of boron (B) that, substitutionally incorporated into 1 kg of germanium (Ge), will establish a charge carrier density of 3.091×10^{17} cm^{-3}.

(b) Draw a schematic energy band diagram for this material, and label all critical features.

Problem #2

(a) An electron beam strikes a crystal of cadmium sulfide (CdS). Electrons scattered by the crystal move at a velocity of 4.4×10^5 m/s. Calculate the energy of the incident beam. Express your result in eV. CdS is a semiconductor with a band gap, E_g, of 2.45 eV.

(b) Cadmium telluride (CdTe) is also a semiconductor. Do you expect the band gap of this material to be greater or less than the band gap of CdS? Explain.

Problem #3

AlN and GaSb are compounds, solid at room temperature. On the basis of bonding considerations and data provided in the periodic table, attempt to predict differences in the properties of these solids.

Problem #4

Explain the difference between extrinsic and intrinsic semiconductors.

Problem #5

The number of electron-hole pairs in intrinsic germanium (Ge) is given by:

$$n_i = 9.7 \times 10^{15}\ T^{3/2}\ e^{-E_g/2KT}\ \left[cm^3\right] \quad (E_g = 0.72\ eV)$$

(a) What is the density of pairs at T = 20°C?

(b) Will (undoped) Ge be a good conductor at 200°C? If so, why?

Problem #6

If no electron-hole pairs were produced in germanium (Ge) until the temperature reached the value corresponding to the energy gap, at what temperature would Ge become conductive? (E_{th} = 3/2 kT)

Problem #7

(a) How do you expect the conductivity to vary in an intrinsic semiconductor with increasing temperature? Explain your answer.

(b) How do you expect the conductivity to vary in a metallic conductor with increasing temperature?

Problem #8

The energy gap (E_g) of ZnSe is 2.3 eV.

(a) Is this material transparent to visible radiation? Substantiate your answer.

(b) How could you increase the electrical conductivity of this material? Give the reasons for the effectiveness of your suggested approach.

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