

3.091 OCW Scholar

Self-Assessment
Electronic Materials

Supplemental Exam Problems for Study

Problem #3

- (a) Germanium is a semiconductor with a band gap energy, E_g , of 0.7 eV. Sketch the absorption spectrum of germanium, i.e., % **absorption** *versus* **wavelength**, λ . Show the value of $\lambda_{\text{abs edge}}$.
- (b) You wish to make *n*-type germanium.
- (i) Name a suitable dopant.
- (ii) Name the majority charge carrier in the doped material.
- (iii) Draw the schematic energy-level diagram of *n*-type germanium indicating electron occupancy at ❶ room temperature (293 K); ❷ elevated temperature (1500 K); ❸ absolute zero (0 K). Label the valence band, conduction band, energy gap, and any energy levels associated with the presence of the dopant. Assume that the positions of the energy levels themselves do not vary with temperature. Show electron occupancy by shading.
- 293 K
1500 K
0 K

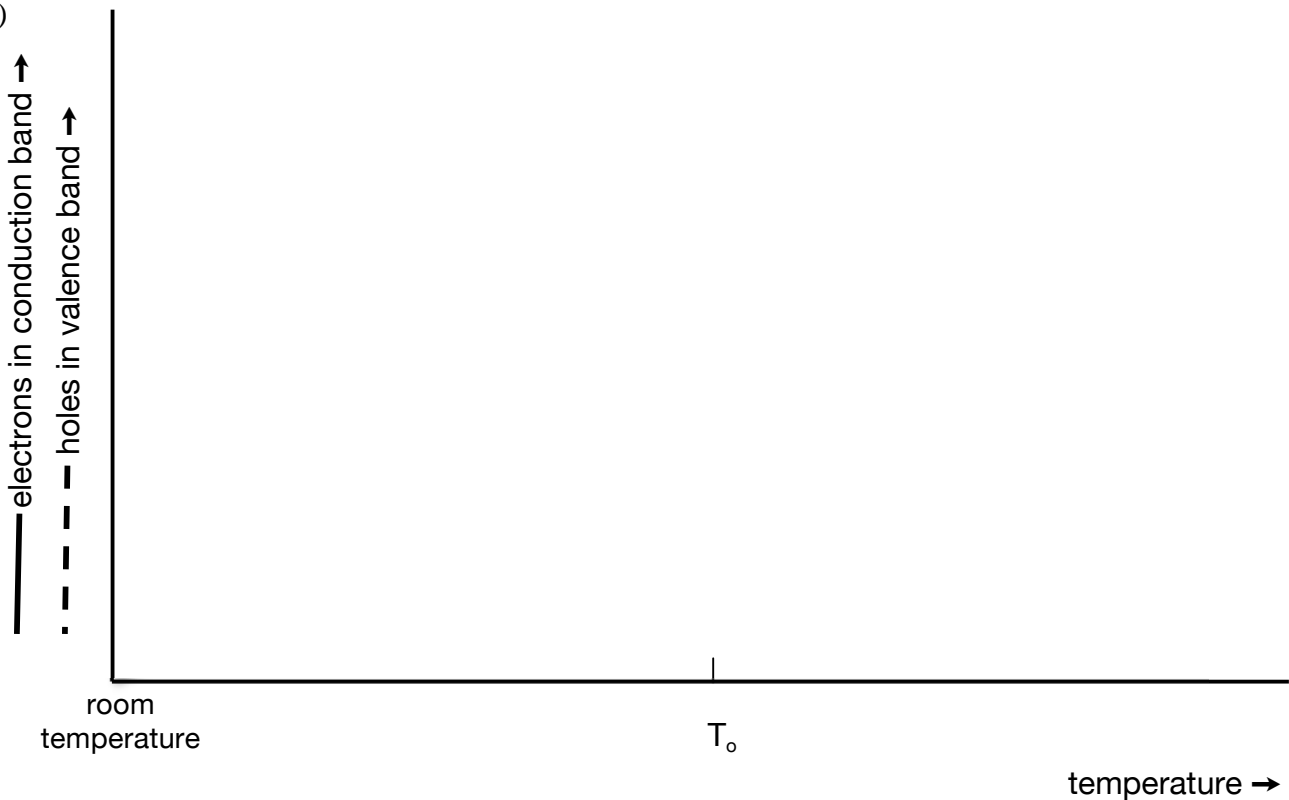
Problem #3

(a) Germanium (Ge) is a semiconductor with a band gap energy, E_g , of 0.7 eV. Ge has been doped with phosphorus (P) to a level of 3.091 mg P / kg Ge. Calculate the charge-carrier population in the doped material. Express your answer in units of carriers/cm³.

(b) Name the dominant charge carrier in P-doped Ge, and specify whether the material is p - or n -type.

(c) For P-doped Ge, on the plot below draw the temperature dependence of ① electrons in the conduction band and ② holes in the valence band. Label clearly each line. T_0 is the temperature at which the contributions to the electrical conductivity from intrinsic and extrinsic behaviors are identical. Be *qualitative* – no calculation necessary.

(8%)



Problem #10

Photovoltaic cells that convert sunlight into electricity are made of silicon (Si) which has a band gap energy (E_g) of 1.1 eV. Night vision systems that identify objects by their thermal radiation have active elements made of indium antimonide (InSb) which has a band gap energy (E_g) of 0.18 eV. Explain the choice of semiconductor in each application.

Photovoltaic cells

Night vision systems

MIT OpenCourseWare
<http://ocw.mit.edu>

3.091SC Introduction to Solid State Chemistry
Fall 2009

For information about citing these materials or our Terms of Use, visit: <http://ocw.mit.edu/terms>.