

Survey of Materials

Homework 3, due date is set in Canvas LMS

Notes: In multiple choice problems explain your answer. Add references if needed. Your solution must be uploaded as a single file “YourName.pdf” or “YourName.zip”.

1. What is not related to electron-phonon interaction: (A) Joule heating; (B) charge carrier concentration; (C) charge carrier mobility; (D) charge carrier effective mass.
2. List materials requirements for phase change memory.
3. List materials requirements for electronic donor in heterojunction solar cells.
4. Which structural types are hardly possible for semiconductors: (A) A1; (B) B1; (C) C1; (D) E1₁; (E) E2₁; (F) A4; (G) B4; (H) C4.
5. Give an example of two classes of materials: one with strongly bound excitons and another with weakly bound ones. Provide rough limits of exciton binding energies for both cases. Support your answer by analytic estimates.
6. Which materials are not π -conjugated: (A) graphene; (B) graphite; (C) diamond; (D) polyyne; (E) polyacetylene; (F) polyethylene; (G) metal-organic frameworks; (H) transition metal dichalcogenides.
7. List three most successful or potentially successful applications or classes of applications of organic semiconductors (excluding graphene).
8. Which of the following applications of carbon nanotubes (as pure material) is the least practical: A) high-endurance mechanical cable; B) conducting wire; C) mechanical deformation sensor; D) gas sensor; E) metal-ion battery electrode.
9. Using Harrison’s parameterization for $pp\pi$ couplings, estimate the bandgap and the total bandwidth of the π -conjugated system of trans-polyacetylene (CC bond lengths are 1.36 and 1.44 Å). Compare with the observed values (1.8 and 12 eV) and comment.
10. What is the main challenge in creating metamaterials for very short wavelengths?