

Try to answer shortly by listing the essential arguments (phenomena, materials properties, other quantities, relations, ...) in a proper order. Short equations and figures with explanations are also a good way to clarify dependencies and trends. The exact forms of different equations are not important but the quantities and their relations needed to describe a phenomenon or property.

1. *Charge carrier densities and mobilities in semiconductors.*

- (a) In which applications direct-band-gap semiconductors can be used, but the indirect band-gap semiconductors cannot? Why? (1 p)
- (b) Consider a semiconductor doped by donor impurities. What is the magnitude of the impurity concentration in typical doping? How do the charge carrier densities and the chemical potential behave as a function of the temperature? (2 p)
- (c) How does the conductivity behave as a function of temperature? What are the temperature dependent quantities and processes affecting the conductivity? (3 p)
- (d) Effective mass theory. What are the basic assumptions and what kind of trends the model explains? (2 p)

2. *pn and hetero junctions.*

- (a) Which are the currents flowing in equilibrium in a pn junction (Explain their origins)? (1 p)
- (b) What are band offsets and band bendings for hetero junctions? On which materials properties they depend on? How the band offsets can be determined for different junctions? (3 p)
- (c) Explain the non-equilibrium model for the electronic structure of a pn junction under an external bias voltage over the junction? What is the meaning of quasi-Fermi levels? (2 p)
- (d) Which are the current components flowing in the case of a pn junction under an external bias voltage over the junction (explain their origins and magnitudes) and the form of the total current? Which are the materials parameters affecting on the total current? (2 p)