Department of Electrical and Computer Engineering
UNIVERSITY OF BRITISH COLUMBIA
EECE 480 SEMICONDUCTOR DEVICES: PHYSICS, DESIGN and ANALYSIS

MID-TERM EXAM, October 20, 2009

Time: 1.25 hours
Notes, books and simple calculators are allowed.
Data-storage- or telecommunication-devices are not allowed.
This exam consists of **1** written page and **1** diagram.

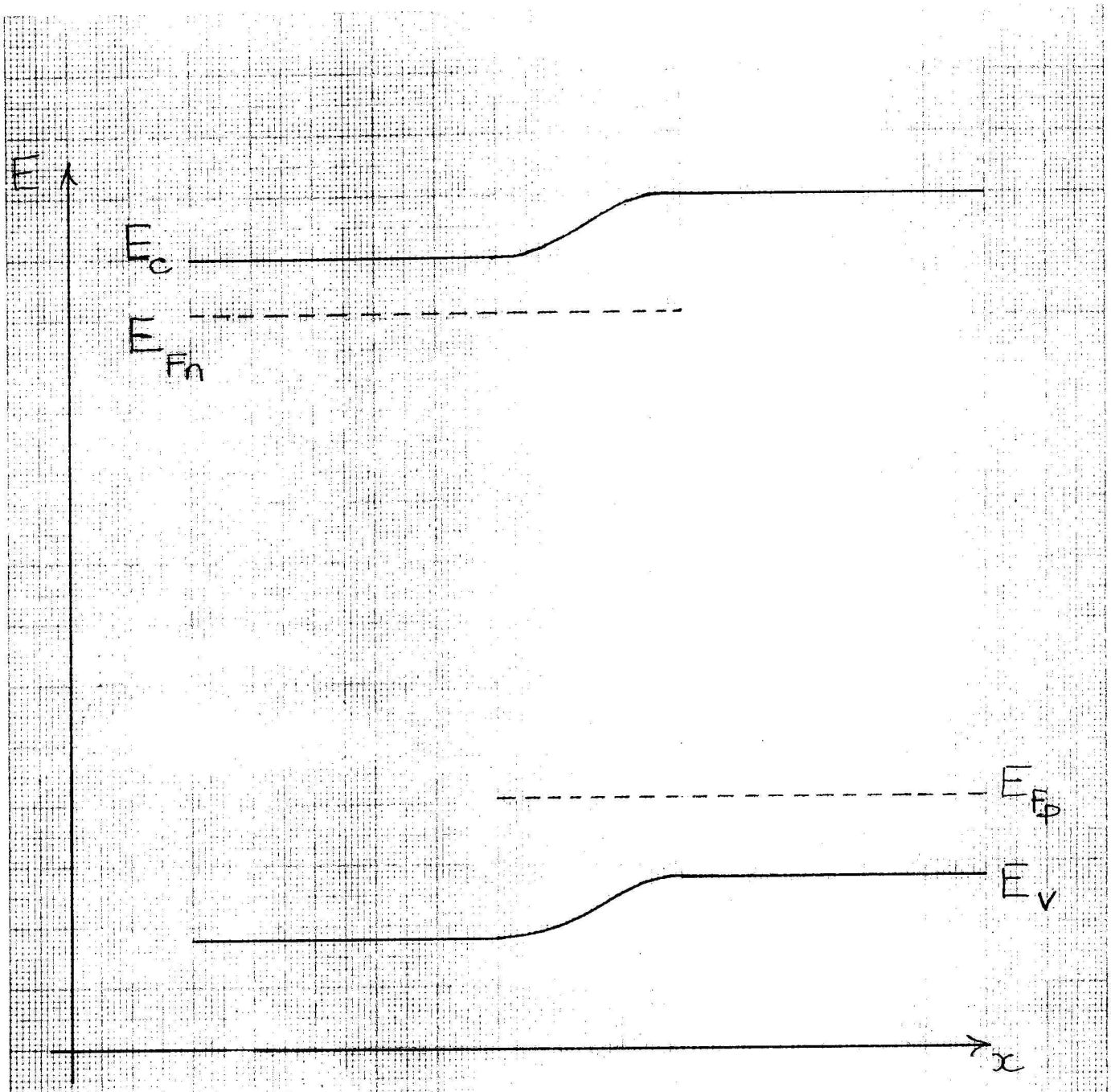
1. [4 marks]
The *E-k* relationships for the conduction bands of two semiconductor materials, A and B, each with spherical constant-energy surfaces, can be expressed as
$E_A - 0.7 = \alpha k^2$ and $E_B - 1.4 = 2\alpha(k - k')^2$,
respectively, where α is a constant, $k' > 0$, and the energies are in units of eV.
Both materials have the same valence-band structure, with the top of the valence band at E=0 and k=0.
Which material has the higher electron mobility?

2. [8 marks]
The partial energy band diagram shown on the back of this page is drawn to scale in the vertical dimension (1 mm≡10 meV). Horizontally, the diagram is only approximately to scale.
From the diagram, determine the following:
(a) whether the semiconductor is silicon or gallium arsenide;
(b) the doping density of the n-region;
(c) the doping density of the p-region;
(d) the applied bias voltage (state whether it is forward or reverse).

3. [8 marks]
(a) Write down the master set of equations, as presented several times in class.
(b) Write down the equations from this set that you would use to solve for the steady-state electron current density in the p-type quasi-neutral region (p-QNR) of a diode.
(c) Write down the boundary conditions for the electron concentration at either end of the p-QNR, given that the back contact is ohmic.
(d) Consider a short-base diode in which the width of the p-QNR is much, much, much less than the electron minority carrier diffusion length.

(i) Sketch the approximate profile of the excess minority carrier concentration ($n_p(x) - n_{0p}$) in the p-QNR.

(ii) Consider the diode to be made from silicon, and to have a p-type doping density of $10^{17}\,\mathrm{cm}^{-3}$, a p-QNR width of 100 nm, and to be subject to a forward bias of —0.8— V
Evaluate the electron current density in the p-type region.



Energy scale: 1 mm ≡ 10 meV