Started on	Thursday, 21 October 2021, 12:10 PM
State	Finished
Completed on	Thursday, 21 October 2021, 12:35 PM
Time taken	25 mins 2 secs
Grade	**5.50** out of 7.00 (**79**%)

Question 1

Not answered

Not graded

Consider that a p-type silicon device is injected with an electron diffusion current of 8 mA. The cross sectional area of the device: 1 mm^2 and the excess electron concentration falls off exponentially with distance from the injecting contact. Assume that:

1. Diffusion coefficient is: 1.2 x $l0^{-3}$ m^2/s, and

2. The excess electron concentration drops to 25% within a distance of 0.5 mm from the contact.,

Now calculate the excess hole concentration at the contact.

Hint:

Flux = I/(q x A); And flux can be determined from diffusion equation also.

I is current, q is charge and A is cross sectional area;

Fundamental Electronic Charge, e = 1.60218 x 10^{-19} C

Electron Rest Mass m_0 = 9.1095 x 10^{-31} kg

Atomic Mass Unit = 1.6606 x 10^{-27} kg

Speed of Light in Vacuum c = 2.99792 x 10^8 $m.s^{-1}$

Planck's Constant h = 6.62617 x 10^{-34} J.s

Wavelength of a 1 eV photon = 1.23977 x 10^{-6} m

1 cm^{-1} = 0.12408 meV

1 meV = 8.0593 cm^{-1}

Boltzmann's Constant k_B = 8.6174 x 10^{-5} $eV.K^{-1}$ = 1.38066 x 10^{-23} $Joules.K^{-1}$

Avogadro's Constant N_A = 6.022 x 10^{26} $(kgMole)^{-1}$

1 Electron Volt eV = 1.60218 x 10^{-19} J

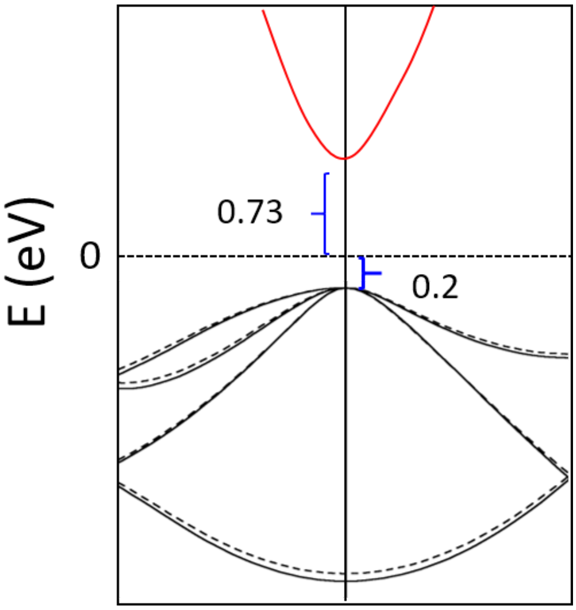
1 kJ / gmole = 1.0364 x 10^{-2} eV / atom

Question **2**

Correct

Mark 1.00 out of 1.00

Correct statement about effective mass of the charge carriers in the following band structure:



Select one:

- a. Effective mass can be +ve as well as -ve also. electrons at the conduction band minimum have a positive effective mass, whereas holes at valence band maximum will have a negative effective mass. ✓
- b. Effective mass only depends on the band structure dispersion. electrons at the conduction band will have -ve effective mass due to -ve charge, whereas holes at valence band will have a +ve effective mass due to +ve charge.
- c. Depending on this curvature of the band structure, electrons will have -ve effective mass at the conduction band minimum, but holes will have +ve effective mass at valence band maximum.
- d. Carrier mass will always be +ve, irrespective of sample parameters.

Your answer is correct.

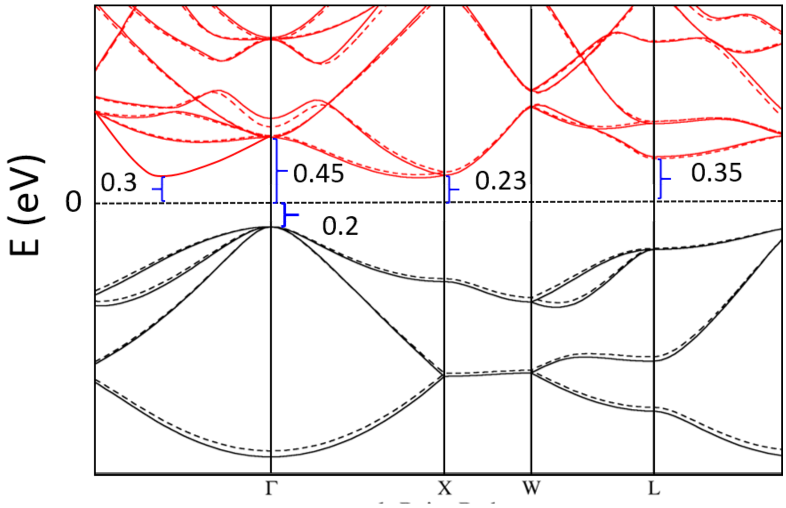
The correct answer is: Effective mass can be +ve as well as -ve also. electrons at the conduction band minimum have a positive effective mass, whereas holes at valence band maximum will have a negative effective mass.

Question 3

Correct

Mark 0.50 out of 0.50

Below is the band structure of a semiconductor:



Identify the correct statement.

Select one:

a. This is an indirect band-gap semiconductor with E_g: 0.45 eV

b. This is an indirect band-gap semiconductor with E_g: 0.43 eV

c. This is an indirect band-gap semiconductor with E_g: 0.23 eV

d. This is a direct band-gap semiconductor with E_g: 0.65 eV

e. This is an indirect band-gap semiconductor with E_g: 0.5 eV

Your answer is correct.

The correct answer is: This is an indirect band-gap semiconductor with E_g: 0.43 eV

Question 4

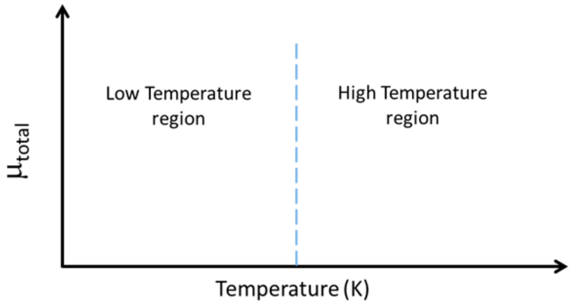
Complete

Mark 1.50 out of 2.00

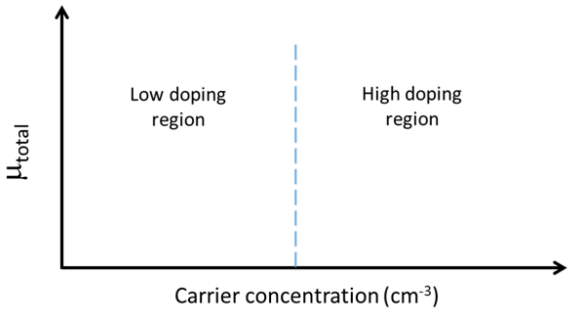
Consider an GaAs extrinsic semiconductor.

A. Plot the temperature dependence of mobility, considering that doping concentration is very low,

(Note that the plot in divided in two regions: low temperature and high temperature as shown in the following plot). Write proper justification for the curves for each section.



B. Now consider a situation that doping is changing in the device with distance. Sketch how the total mobility will vary with increasing carrier doping at fixed temperature, 200 K. Write proper justification.



Note: Marks for each plot will be given only when both the regions are correctly drawn. no marks will be given without Proper written justification.

***In order to avoid confusion and loose of marks, use a scale to draw the lines.**

Comment:
Wrong answer for lower T

Question 5

Incorrect

Mark 0.00 out of 1.00

A device is made of silicon semiconductor, which is doped with (7×10^{15}) cm^{-3} Fe atoms. The device is working at 1000 ^{o}C. Identify the correct statement under fully ionized condition.

intrinsic carrier concentration at 300 K: 1 .4 x 10^{10} cm^{-3}

Select one:

- a. Carriers will appear after applying external electric field.
- b. Minority carriers are electron type with concentration: 1×10^{4} cm^{-3}.
- c. Majority carriers are electron type with concentration: 7×10^{15} cm^{-3}.
- d. Majority carriers are hole type with concentration: 7×10^{21} m^{-3}.
- e. Minority carriers are hole type with concentration: 2.8×10^{4} cm^{-3}. ✗
- f. No majority charge carriers. Device behave like an intrinsic semiconductor.

Your answer is incorrect.

The correct answer is: No majority charge carriers. Device behave like an intrinsic semiconductor.

Question 6

Correct

Mark 1.00 out of 1.00

Which statement is true for the Fermi-level?

Select one:

- a. Fermi-level is the reference level where probability of finding an electron is 1/2 at a particular temperature, 300 K. Probability of electron (hole) occupancy changes linearly above (below) the Fermi level.
- b. Fermi-level is a fixed energy level and cannot be changed anyhow by any means in a semiconductor device.
- c. Fermi level always appears at the middle of the band diagram of a semiconductor. Position is independent of the doping type or dopant concentration.
- d. Fermi-level is simply one reference level which can appear at different places on a semiconductor energy-band diagram depending on the doping conditions. So, probability of one electron occupancy at $+\Delta E$ above Fermi level is the same of a hole occupancy at $-\Delta E$ below the Fermi-level. ✓

Your answer is correct.

The correct answer is: Fermi-level is simply one reference level which can appear at different places on a semiconductor energy-band diagram depending on the doping conditions. So, probability of one electron occupancy at $+\Delta E$ above Fermi level is the same of a hole occupancy at $-\Delta E$ below the Fermi-level.

Question 7

Correct

Mark 1.00 out of 1.00

In connection with the conductivity of the charge carriers in a semiconductor device, identify which of the following statement is correct:

Select one:

- a. Mobility of the charge carriers can be different along different crystallographic directions. Such anisotropic behavior is deeply connected the curvature and dispersion of the associated band structure. ✓
- b. Carrier mobility can be anisotropic only-if we can design an artificial lattice where the scattering cross section is changed along different directions.
- c. Carrier mobility is isotropic with respect to any crystallographic direction. Carriers are free to move anywhere in the device.
- d. Carrier mobility is dependent only on the strength of the external electric field. system parameters doesn't matter.

Your answer is correct.

The correct answer is: Mobility of the charge carriers can be different along different crystallographic directions. Such anisotropic behavior is deeply connected the curvature and dispersion of the associated band structure.

Question 8

Correct

Mark 0.50 out of 0.50

In a Silicon device, electrons and hole carriers have mobilities of 0.11 m^2/V s and 0.02 m^2/V s respectively. Which of the following statement is correct for carrier diffusion:

Select one:

- a. Electrons diffuse faster than holes in the device. ✓
- b. Holes diffuse faster than electrons in the device.
- c. Carriers can't diffuse unless an external electric field is applied.
- d. Carrier diffusion rates of electrons and holes can be same, depending on the device temperature.
- e. Carrier diffusion rate is equal for all types of carriers.

Your answer is correct.

The correct answer is: Electrons diffuse faster than holes in the device.

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