Started on	Monday, 22 November 2021, 9:15 AM
State	Finished
Completed on	Monday, 22 November 2021, 11:25 AM
Time taken	2 hours 10 mins
Grade	**37.50** out of 48.00 (**78**%)

Question 1

Complete

Mark 3.00 out of 4.00

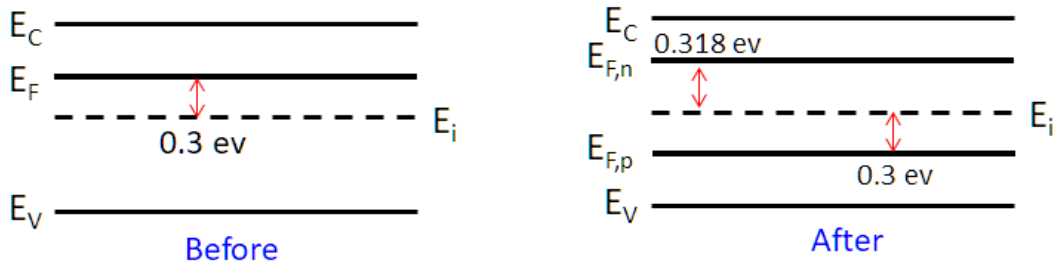
A semiconductor device is illuminated with a light at 300 K such that the equilibrium and steady state conditions before and after illumination is characterized by the energy band diagrams shown below. Consider: $n_i = 10^{10}$ cm^{-3}, μ_n = 1100 cm^2/V-s, and μ_p = 400 cm^2/V-s. $E_{F,n}$ and $E_{F,p}$ are the Fermi levels for n & p carriers after the illumination.

(a) Calculate the equilibrium carrier concentrations, n_0 and p_0 before illumination.

(b) Calculate the modified carrier concentrations, n and p after illumination under steady state.

(c) Calculate the resistivity of the semiconductor before and after illumination.

Symbols in the following diagram carry usual meaning. Write proper units.



(1+1+2)

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

Comment:
have to calculate value
& unit??

Question 2

Complete

Mark 3.00 out of 3.00

Consider the Kronig-Penney potential with the condition P<<1. Find the energy of the lowest band at k=0?

Comment:

Question 3

Correct

Mark 0.50 out of 0.50

For ferroelectric materials, which statement is correct in Curie-Weiss law

Select one:

- a. Applicable to ferroelectric region
- b. Applicable to paraelectric region ✓
- c. Susceptibility is directly proportional to Curie Temperature
- d. Applicable to both ferroelectric and paraelectric region

Your answer is correct.

The correct answer is: Applicable to paraelectric region

Question 4

Correct

Mark 1.00 out of 1.00

For a n-type extrinsic semiconductor which of the following statement is correct?

Select one:

- a. Both the conduction band and acceptor level take equally active part in current conduction.
- b. Electrical conductivity in the donor level of the device can be controlled by external electrical field.
- c. The electrical conduction is controlled and mediated by the acceptor level or the donor level whichever is created.
- d. A donor level is created which doesn't take part in the electrical conduction. However this can be tuned by changing the doping concentration. ✓
- e. The acceptor level doesn't take part in the electrical conduction. It remains electrically inert unless the acceptor concentrations comes to within a few percent of the host semiconductor atom concentrations.

Your answer is correct.

The correct answer is: A donor level is created which doesn't take part in the electrical conduction. However this can be tuned by changing the doping concentration.

Question 5

Complete

Mark 2.00 out of 2.00

Consider that a semiconductor device is exposed to a light with wavelength range: (λ = 0.45 – 0.9 μm). Find out which of the semiconductors among Si, GaAs, GaP, and GaN are transparent, partially transparent and non-transparent?

Write proper justification. No marks will be given without justification.

Bandgap of popular semiconductors:

Si: 1.12 eV

GaAs: 1.42 eV

GaN: 3.44 e V

GaP: 2.26 eV

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1 Electron Volt eV = 1.60218×10^{-19} J
1 kJ / gmole = 1.0364×10^{-2} eV / atom

Comment:

Question 6

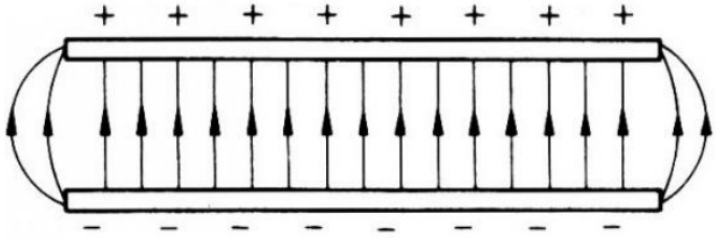
Correct

Mark 1.00 out of 1.00

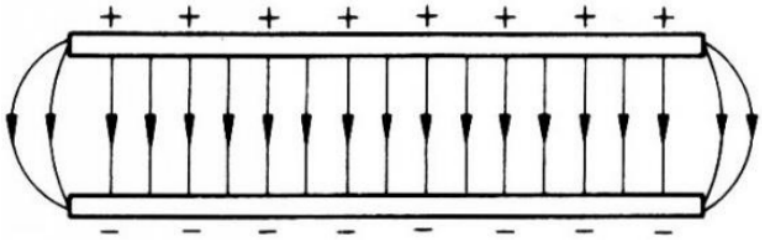
Which of the following diagrams most accurately portrays the electric field of a capacitor?

Select one:

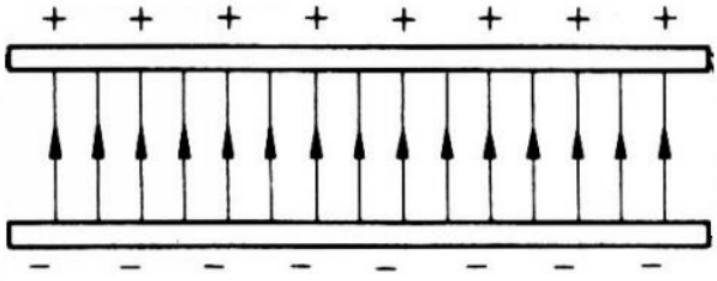
a.



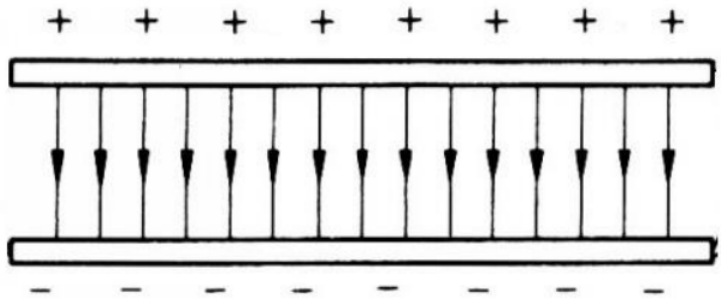
b.



c.

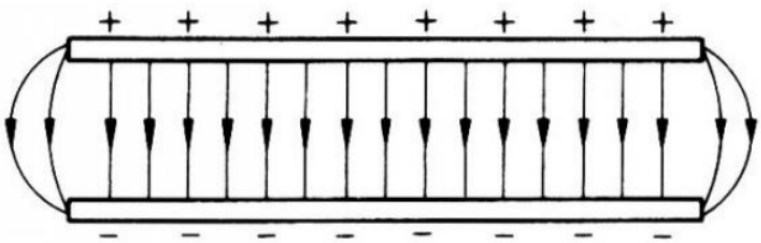


d.



Your answer is correct.

The correct answer is:

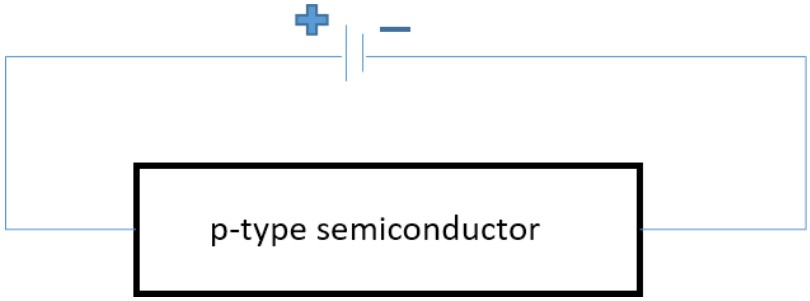


Question 7

Correct

Mark 1.00 out of 1.00

Consider a device connected in the following manner:



Select which of the following option is correct. e is electron and h is hole. The arrow shows movement of the corresponding charge carriers. Consider the following energies for:

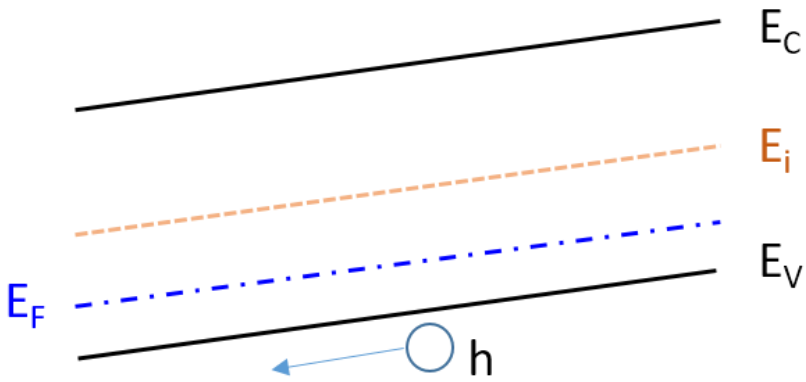
E_C: Conduction band

E_V: Valance Band

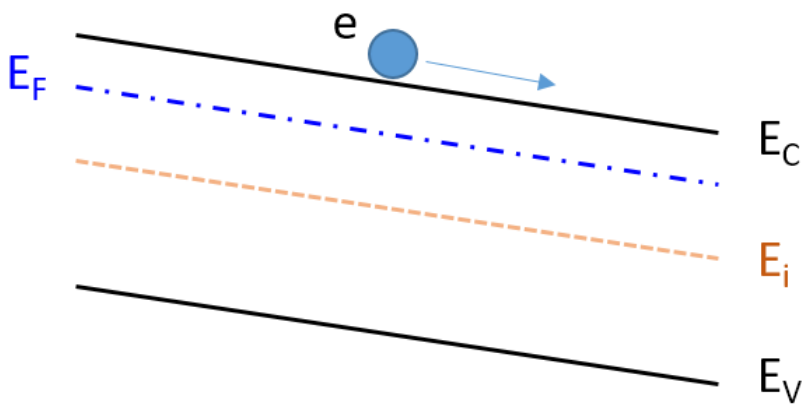
E_F: Fermi energy

E_i: Fermi-level in an intrinsic semiconductor

Select one:

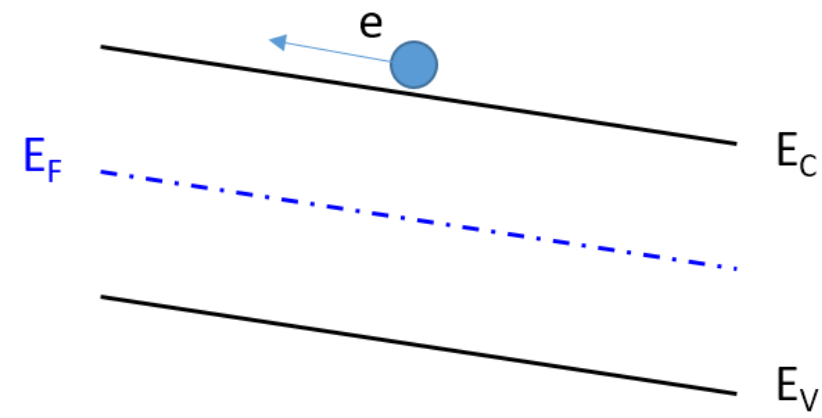


a.

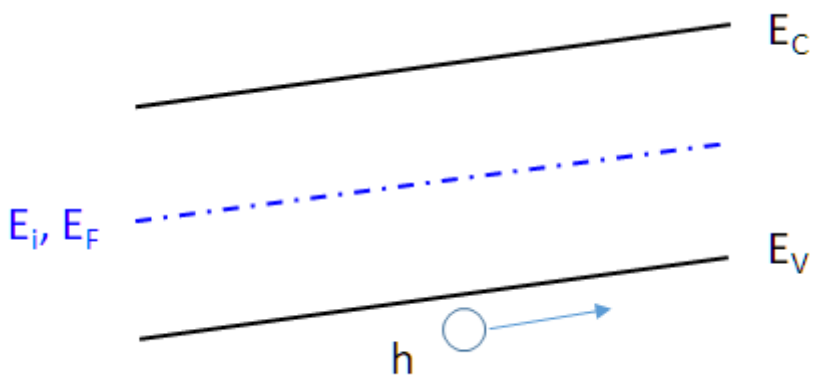


b.

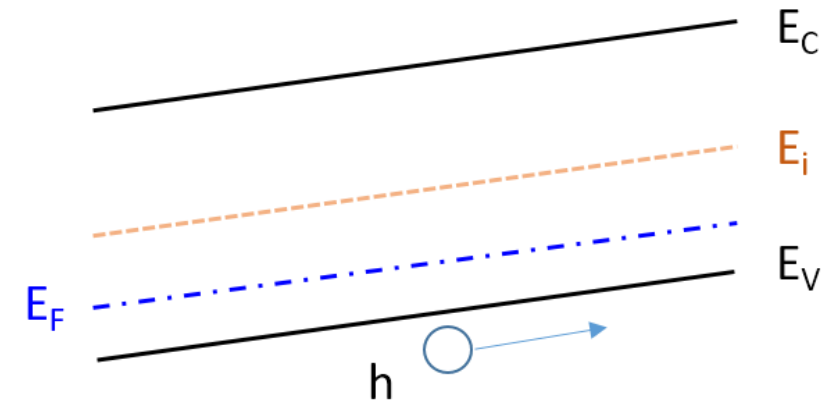
c.



d.

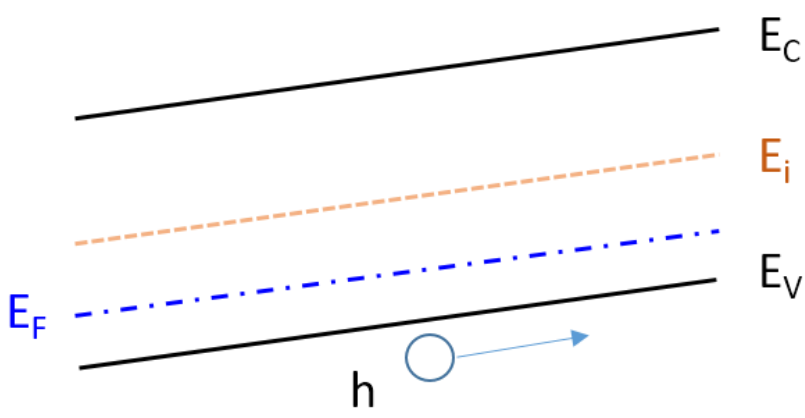


e. ✓



Your answer is correct.

The correct answer is:



Question 8

Incorrect

Mark 0.00 out of 1.00

Ferroelectric materials exhibit which of the following polarization

Select one:

- a. permanent ✗
- b. Ionic
- c. remanent
- d. atomic

Your answer is incorrect.

The correct answer is: remanent

Question 9

Not answered

Not graded

Here you can combine all Essay answers and upload as a single file.

Remember: It's your duty to write question no. correctly in each paper and arrange properly. No further post-exam request/query will be entertained on this.

Question 10

Correct

Mark 0.50 out of 0.50

In a dielectric, dipole moment per unit volume is

Select one:

- a. Permittivity
- b. Polarization ✓
- c. Susceptibility
- d. Charge Density

Your answer is correct.

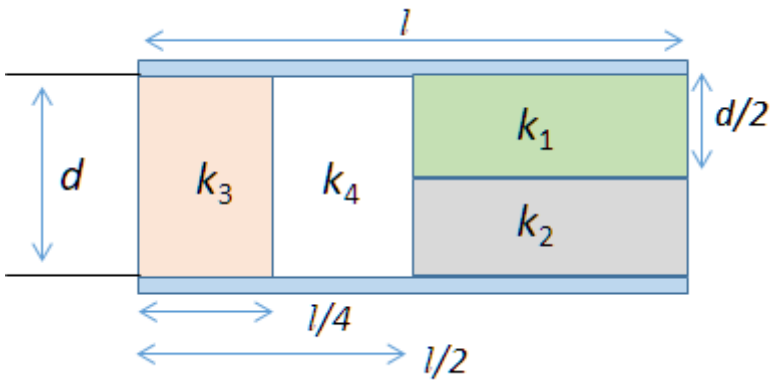
The correct answer is: Polarization

Question 11

Complete

Mark 2.50 out of 2.50

Consider that, a parallel-plate capacitor is constructed by filling the space between two square plates with blocks of Four dielectric materials, as in the figure below. Find the equivalent capacitance of the device in terms of the plate area: A, plate separation: d, and respective dielectric constants: k_1, k_2, $k_3$and k_4.



Comment:

Question 12

Correct

Mark 1.00 out of 1.00

For a p-n junction, identify the correct statement:

Select one:

- a. Built-in voltage is maximum under the forward bias. However the value can be engineered by the either side external doping.
- b. Band gap is independent of the junction's built-in voltage. It can be higher than E_g concerted to volts depending on the external reverse bias.
- c. The built-in potential is typically less than the band gap energy converted to volts. Besides, its value remains unchanged whether any ohmic contacts given to the device or not. ✓
- d. Maximum built-in potential across the p-n junction can be upto the band gap energy concerted to volts. However, resistance of the ohmic contacts given to the device reduce the built-in voltage drop across the junction.

Your answer is correct.

The correct answer is: The built-in potential is typically less than the band gap energy converted to volts. Besides, its value remains unchanged whether any ohmic contacts given to the device or not.

Question 13

Complete

Mark 1.50 out of 5.50

Consider that a Si has the following band diagram and is maintained at 300 K.

(a) Identify whether sample is at equilibrium or not. Write justification.

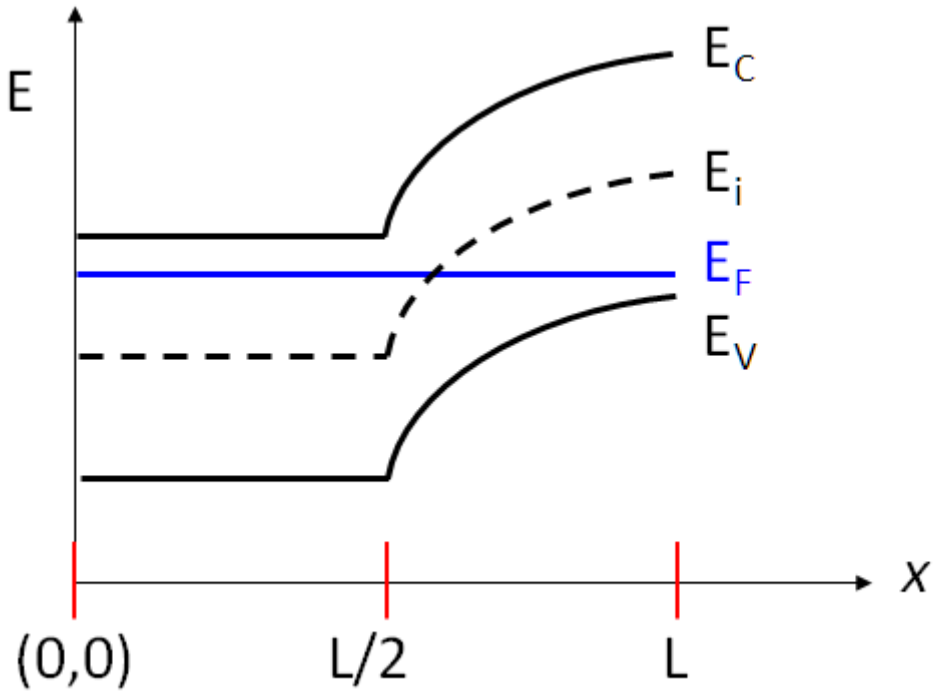
(b) Sketch the electric field inside the semiconductor as a function of *x*.

(c) Roughly sketch n and p with respect to *x*.

(d) Plot a schematic diagram of the electron drift-current density ($J_{n,Drift}$) and the electron's diffusion-current density ($J_{n,Diff}$) inside the Si sample as a function of *x*. Note, take care of the proper sign in the plot. Briefly justify how you arrived to your sketch.

No marks will be given without the justification in each section. Clearly mark the position 0, L/2 & L along x axis in each plots.

Symbols in the following diagram carry usual meaning.



(0.5+1+2+2)

Comment:
c & D are not correct

Question 14

Complete

Mark 4.00 out of 4.00

Assume that the electrostatic potential across the depletion region of a pn junction diode under equilibrium is given as:

$$V(x) = \frac{V_{bi}}{2}\left[1 + \sin\left(\frac{\pi x}{W}\right)\right]$$, in -W/2 ≤ *x* ≤ +W/2, where W is the total width of the depletion region.

(a) Find out the expression for the electric field (Σ) as a function of position in the depletion region, (-W/2 ≤ *x* ≤ +W/2) and sketch Σ(*x*) versus *x*. Clearly mark ±W/2 in the plot.

(b) Establish an expression for the charge density (ρ) as a function of position in the depletion region and sketch ρ(*x*) versus *x*. Note that, according to the Poisson's equation, dΣ/d*x* = ρ/a; where a is a constant.

Rest symbols carry usual meaning and take care of the respective signs.

(1+1+1+1)

Comment:

Question 15

Complete

Mark 3.00 out of 3.00

Consider that, a parallel plate capacitor (filled with vacuum) has capacitance C. Assume that it is fully charged with the help of a battery and then disconnected. The plates are then pulled apart by an extra distance d, due to which, the measured potential difference between them is increased by a factor of 7. Calculate the total volume of the dielectric necessary to fill the region between the plates, after the modification made.

Note: The answer should be given only in terms of the variables defined in the Problem, fundamental constants and numbers only.

Comment:

Question 16

Correct

Mark 0.50 out of 0.50

Across a material of low permittivity, the potential gradient will be .... compared to the material of high permittivity.

Select one:

- a. equal
- b. smaller
- c. greater ✓
- d. The statement is not true: potential gradient does not depend on permittivity

Your answer is correct.

The correct answer is: greater

Question 17

Complete

Mark 1.50 out of 1.50

Calculate electron velocity in a n-type silicon piece due to the thermal energy at 100 K temperature.

Assume that carrier energy per degree of freedom is ($K_B T/2$) and electron effective electron mass is 1.5 m_o

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1 Electron Volt eV = 1.60218×10^{-19} J
1 kJ / gmole = 1.0364×10^{-2} eV / atom

Comment:

Question 18

Correct

Mark 0.50 out of 0.50

In an extrinsic semiconductor identify which statement is true.

Select one:

- a. The Drift and Diffusion current are connected with each other. If one increases, the other will also increase depending on the carrier mobility or curvature of respective band structure. ✓
- b. The Drift and Diffusion currents are independent of each other. Once can tune either of them independently by tuning the dopant atom's mobility, concentration etc.
- c. The Drift and Diffusion current are independently controlled by the curvature of the respective carrier's band structure.
- d. The Drift and Diffusion currents are two independent parts of semiconductor device which can be tuned only by external electric field.
- e. The Drift and Diffusion current are controlled by the carrier effective mass. Both current increases with increase of the effective mass.

Your answer is correct.

The correct answer is: The Drift and Diffusion current are connected with each other. If one increases, the other will also increase depending on the carrier mobility or curvature of respective band structure.

Question 19

Complete

Mark 4.00 out of 4.00

Consider that a Si made device of length L is maintained under equilibrium conditions at room temperature. However, a nonuniform acceptor doping is created such that:

$p(x) = n_i e^{(a-x)/b}$, with $0 \le x \le L$;

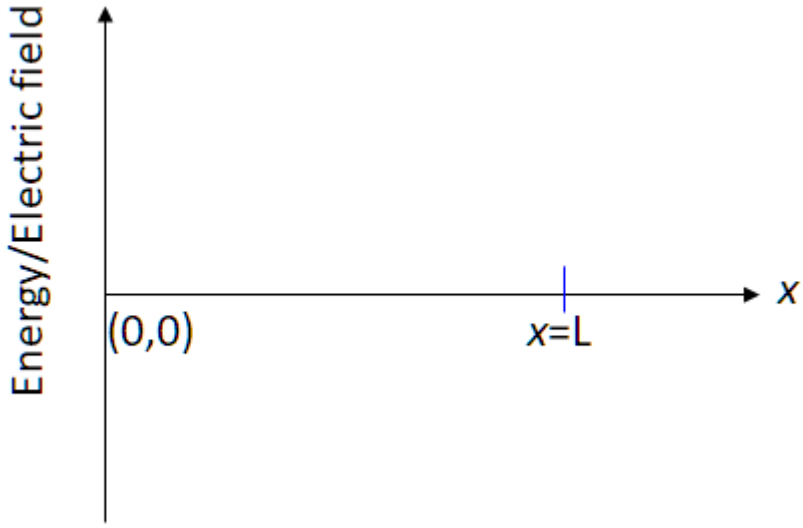
Here a = 1.8 μm, b = 0.1 μm, and L = 0.8 μm. Rest carry usual meanings. Assume that both hole and electrons have very similar effective masses.

(a) Draw the schematic energy band diagram in the region $0 \le x \le L$ in the following format. Particularly show E_F, E_C, E_V and E_i. Explain how you arrived at your diagram. **No marks will be given without the justification.**

Also, mention the (E_i-E_F) value at $x = 0$ and $x = L$.

(b) Plot the electric field inside the region as a function of position in the same format.

No marks will be given without the justification in both sections.



2.5+1.5

Comment:

Question 20

Correct

Mark 1.00 out of 1.00

For a p-n junction under the forward and reverse biased, identify the correct statement:

Select one:

- a. Forward bias enhances majority hole injection from p-side to n-side, increasing the associated drift current. However, diffusion current remains the same like the reverse bias.
- b. Under the forward bias, both diffusion and drift current increases. However for reverse bias, the junction potential increases, resulting low diffusion and drift current.
- c. Large and dominating diffusion current in the forward bias condition due to enhanced hole diffusion from p-side to n-side. However, in reverse bias, drift current dominates over the diffusion current due to enhanced barrier potential height. ✓
- d. Forward bias enhances injection of minor electrons from p-side to n-side resulting higher diffusion and drift current compared to the reverse bias.

Your answer is correct.

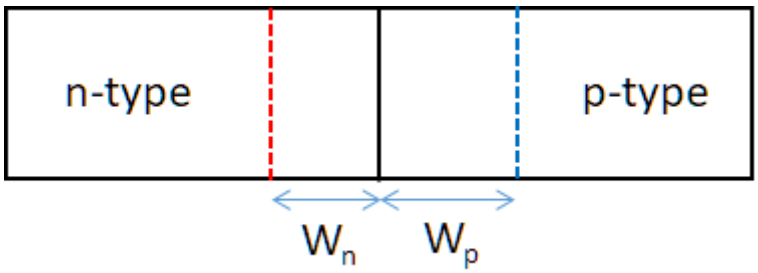
The correct answer is: Large and dominating diffusion current in the forward bias condition due to enhanced hole diffusion from p-side to n-side. However, in reverse bias, drift current dominates over the diffusion current due to enhanced barrier potential height.

Question 21

Complete

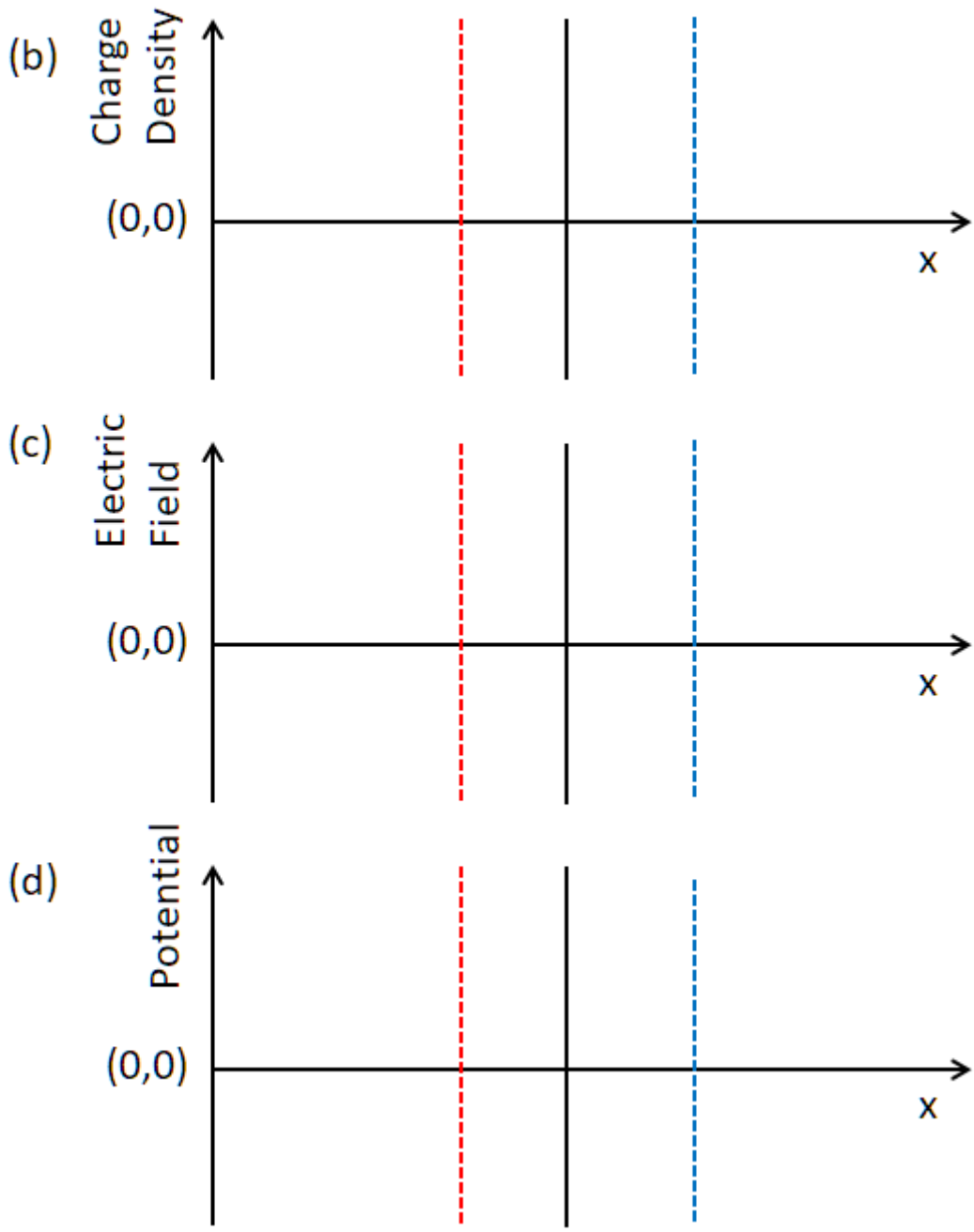
Mark 3.00 out of 4.00

Consider the following n-p junction where W_n and W_p are the corresponding depletion widths with $W_n<W_p$:



answer the question and plot the schematics of Charge density, electric field and potential across the junction in the following format. Color schemes represents the usual meaning:

(a) If N_p and N_n are the doping concentration in the p and n sides respectively, then write whether ($N_p = N_n$) or ($N_p > N_n$) or ($N_p < N_n$).



1+1+1+1

Comment:
d wrong

Question 22

Correct

Mark 1.00 out of 1.00

Materials with permeability less than the permeability of free space, are known as

Select one:

- a. Paramagnetic
- b. Antiferromagnetic
- c. Ferromagnetic
- d. Diamagnetic ✓
- e. Ferrimagnetic
- f. Such type of materials does not exist.

Your answer is correct.

The correct answer is: Diamagnetic

Question 23

Not answered

Marked out of 3.00

Consider Fe_3O_4 solid and find the saturated magnetic moment (spin only) per molecule.

Question 24

Incorrect

Mark 0.00 out of 0.50

In Ferroelectric materials, the polarization is

Select one:

- a. None of the above
- b. Reversible
- c. Linear
- d. Permanent ✗

Your answer is incorrect.

The correct answer is: Reversible

Question 25

Correct

Mark 1.00 out of 1.00

An increasing external electric field is applied to a semiconductor device. Identify the correct statement:

Select one:

- a. Initially drift velocity increases linearly. However at very high electric field, drift velocity cannot exceed the carrier's thermal velocity. Excess energy will heat-up the device. ✓
- b. Electric field will have no effect on carrier movement, since the thermal energy scatters all the carriers.
- c. At a certain very high electric field, carriers will overcome the effect of thermal scattering. There-after drift velocity will increase linearly with respect to the applied electric field.
- d. External electric field increases the carrier's drift velocity. It can increase indefinitely depending on the applied field.

Your answer is correct.

The correct answer is: Initially drift velocity increases linearly. However at very high electric field, drift velocity cannot exceed the carrier's thermal velocity. Excess energy will heat-up the device.

Question 26

Correct

Mark 1.00 out of 1.00

Which of the following statements are true?

(i) The units of displacement field D and polarization P are different.

(ii) The external charge on the surface of the polarized dielectric is free.

(iii) In vacuum P=0, therefore E can be written as D/ϵ_0.

(iv) If the electric susceptibility of a dielectric is 7, its relative permittivity is 6.

Select one:

- a. (i)
- b. (i) and (iii)
- c. (i) and (ii)
- d. (iii) and (iv)
- e. (iii) ✓
- f. (ii) and (iv)
- g. (iv)
- h. (ii)

Your answer is correct.

The correct answer is: (iii)

◀ General Relation of n & p

Jump to...