CONDUCTION OF ELECTRICITY IN SOLIDS

In a pure metal the collisions that are characterized by the mean free time τ in the expression for the resistivity are chiefly between:

electrons and other electrons
electrons with energy about equal to the Fermi energy and atoms
all electrons and atoms
electrons with energy much less than the Fermi energy and atoms
atoms and other
atoms ans: B

A certain metal has 5.3×10^{29} conduction electrons/m^3 and an electrical resistivity of 1.9×10^{-9} Ω · m. The average time between collisions of electrons with atoms in the metal is:

5.6×10^{-33} s
1.3×10^{-31} s
9.9×10^{-22} s
4.6×10^{-15} s
3.5×10^{-14}
s ans: C

Which one of the following statements concerning electron energy bands in solids is true?

The bands occur as a direct consequence of the Fermi-Dirac occupancy probability function
Electrical conduction arises from the motion of electrons in completely filled bands
Within a given band, all electron e ergy levels are equal to each other
An insulator has a large energy separat on between the highest filled band and the lowest empty band
Only insulators have energy ba
ds ans: D

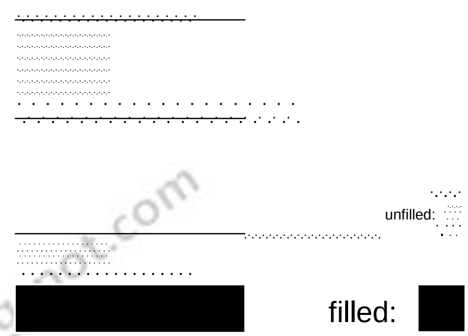
If E_0 and E_T are the average energies of the "free" electrons in a metal at 0 K and room temperature, respectively, then the ratio E_T / E_0 is approximately:

0
1
100
10^6
infinity
ans: B

The energy gap (in eV) between the valence and conduction bands of an insulator is of the order of:

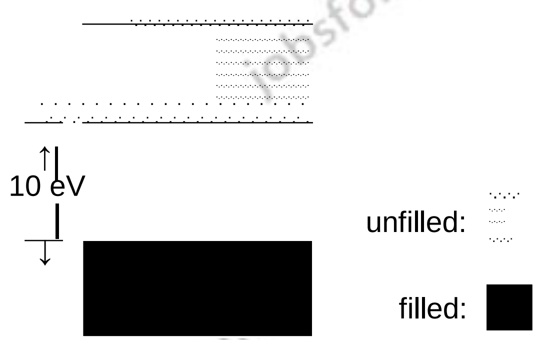
10^{-19}
0.001
0.1
10
1000
ans: D

. The energy level diagram shown applies to:



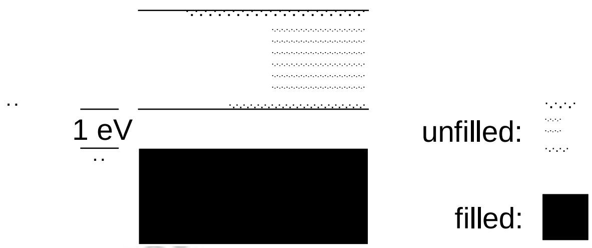
a conductor
an insulator
a semiconductor
an isolated molecule
an isolated
atom ans: A

The energy level diagram shown applies to:



a conductor
an insulator
a semiconductor
an isolated atom
a free-electron
gas ans: B

. The energy level diagram shown applies to:



a conductor
an insulator
a semiconductor
an isolated molecule
an isolated atom ans: C

Possible units for the density of states function N(E) are:

J/m^3
$1/J$
m^{-3}
$J^{-1} \cdot m^{-3}$
kg/m^3
ans: D

The density of states for a metal depends primarily on:

the temperature
the energy
the density of the metal
the volume of the sample
none of these ans: B

The Fermi-Dirac occupancy probability P (E) varies between:

0 and 1
0 and infinity
1 and infinity
−1 and 1
0 and E_F
ans: A

For a metal at absolute temperature T , with Fermi energy E_F , the occupancy probability is given by:

$e^{(E-E_F)/kT}$

$e^{-(E-E_F)/kT}$

C. $\frac{1}{e^{(E-E_F)/kT}+1}$

D. $\frac{1}{e^{-(E-E_F)/kT}+1}$

E. $\frac{1}{e^{(E-E_F)/kT}-1}$

ans: C

In a metal at 0 K, the Fermi energy is:

the highest energy of any electron
the lowest energy of any electron
the mean thermal energy of the electrons
the energy of the top of the valence band
the energy at the bottom of the conduction band
ans: A

The occupancy probability for a state with energy equal to the Fermi energy is:

0
0.5
1
1.5
2
ans: B

The Fermi energy of a metal depends primarily on:

the temperature
the volume of the samp e
the mass density of the met l
the size of the sample
the number density of conduction electrons ans: E

The speed of an electron with energy equal to the Fermi energy for copper is on the order of:

10^6 m/s
10^{-6} m/s
10 m/s
10^{-1} m/s
10^9 m/s
ans: A

At T = 0 K the probability that a state 0.50 eV below the Fermi level is occupied is about:

0
5.0×10^{-9}
5.0×10^{-6}
5.0×10^{-3}
1
ans: E

. At T = 0 K the probability that a state 0.50 eV above the Fer i level is occupied is about:

0
5.0×10^{-9}
5.0×10^{-6}
5.0×10^{-3}
1
ans: A

At room temperature kT is about 0.0259 eV. The probability that a state 0.50 eV above the Fermi level is occupied at room temperature is:

1
0.05
0.025
5.0×10^{-6}
4.1×10^{-9}
ans: E

At room temperature kT is about 0.0259 eV. The probability that a state 0.50 eV below the Fermi level is unoccupied at room temperature is:

1
0.05
0.025
5.0×10^{-6}
4.1×10^{-9}
ans: E

If the density of states is N(E) and the occupancy probability is P (E), then the density of occupied states is:

N(E) + P(E)
N(E)/P (E)
N(E) − P(E)
N(E)P (E)
P (E)/N(E)
ans: D

A hole refers to:

a proton
a positively charged electron
an electron that has somehow lost its charge
a microscopic defect in a solid
the absence of an electron in an otherwise filled band ans: E

Electrons in a full band do not contribute to the current when an electric field exists in a solid because:

the field cannot exert a force on them
the individual contributions cancel each other
they are not moving
they make transitions to other bands
they leave the solid ans: B

For a pure semiconductor the Fermi level is:

in the conduction band
well above the conduction band
in the valence band
well below the valence band
near the center of the gap between the valence and conduction bands ans: E

The number density n of conduction electrons, the resistivity ρ, and the temperature coefficient of resistivity α are given below for five materials. Which is a semiconductor?

$n = 10^{29}\ m^{-3}$, $\rho = 10^{-8}\ \Omega \cdot m$, $\alpha = +10^{-3}\ K^{-1}$
$n = 10^{28}\ m^{-3}$, $\rho = 10^{-9}\ \Omega \cdot m$, $\alpha = -10^{-3}\ K^{-1}$
$n = 10^{28}\ m^{-3}$, $\rho = 10^{-9}\ \Omega \cdot m$, $\alpha = +10^{-3}\ K^{-1}$
$n = 10^{15}\ m^{-3}$, $\rho = 10^{3}\ \Omega \cdot m$, $\alpha = -10^{-2}\ K^{-1}$
$n = 10^{15}\ m^{-3}$, $\rho = 10^{-7}\ \Omega \cdot m$, $\alpha = +10^{-3}\ K^{-1}$
ans: D

A pure semiconductor at room temperature has:

more electrons/m^3 in its conduction band than holes/m^3 in its valence band
more electrons/m^3 in its conduction band than a typical metal
more electrons/m^3 in its valence band than at T = 0 K
more holes/m^3 in its valence band than electrons/m^3 in its valence band
none of the above ans: E

For a metal at room temperature the temperature coefficient of resistivity is determined primarily by:

the number of electrons in the conduction band
the number of impurity atoms
the binding energy of outer shell electrons
collisions between conduction electrons and atoms
none of the
above ans: D

For a pure semiconductor at room temperature the temperature coefficient of resistivity is determined primarily by:

the number of electrons in the conduction band
the number of replacement atoms
the binding energy of outer shell electrons
collisions between conduction electrons and atoms
none of the
above ans: A

A certain material has a resistivity of $7.8 \times 10^{3}\ \Omega \cdot$ m at room temperature and it increases as the temperature is raised by 100° C. The mate ial is most likely:

a metal
a pure semiconductor
a heavily doped semiconductor
an insulator
none of the
above ans: C

A certain material has a resistivity f $7.8 \times 10^{3}\ \Omega \cdot$ m at room temperature and it decreases as the temperature is raised by 100° C. The material is most likely:

a metal
a pure semiconductor
a heavily doped semiconductor
an insulator
none of the
above ans: B

A certain material has a resistivity of $7.8 \times 10^{-8}\ \Omega \cdot$ m at room temperature and it increases as the temperature is raised by 100° C. The material is most likely:

a metal
a pure semiconductor
a heavily doped semiconductor
an insulator
none of the
above ans: A

Donor atoms introduced into a pure semiconductor at room temperature:

increase the number of electrons in the conduction band
increase the number of holes in the valence band
lower the Fermi level
increase the electrical resistivity
none of the
above ans: A

Acceptor atoms introduced into a pure semiconductor at room te perature:

increase the number of electrons in the conduction band
increase the number of holes in the valence band
raise the Fermi level
increase the electrical resistivity
none of the
above ans: B

An acceptor replacement atom in silicon might have ____ electrons in its outer shell.

3
4
5
6
7
ans: A

A donor replacement atom in silicon might have ____ electrons in its outer shell.

1
2
3
4
5
ans: E

A given doped semiconductor can be identified as p or n type by:

measuring its electrical conductivity
measuring its magnetic susceptibility
measuring its coefficient of resistivity
measuring its heat capacity
performing a Hall effect
experiment ans: E

The contact electric field in the depletion region of a p-n junction is produced by:

electrons in the conduction band alone
holes in the valence band alone
electrons and holes together
charged replacement atoms
an applied bias potential
difference ans: D

For an unbiased p-n junction, the energy at the bottom of the conduction band on the n side is:

higher than the energy at the bottom of the conduction band on the p side
lower than the energy at the bottom of the conduction band on the p side
lower than the energy at the top of the valence band on the n side
lower than the energy at the top of the valence band on the p side
the same as the energy at the bottom of the conduction band on the p
side ans: B

In an unbiased p-n junction:

the electric potential vanishes everywhere
the electric field vanishes everywhere
the drift current vanishes everywhere
the diffusion current vanishes everywhere
the diffusion and drift currents cancel each
other ans: E

Application of a forward bias to a p-n junction:

narrows the depletion zone
increases the electric field in the depletion zone
increases the potential difference across the d pletion zone
increases the number of donors on the n side
E. decreases the number of donors on the side
ans: A

Application of a forward bias to a p- ju ction:

increases the drift current in the depletion zone
increases the diffusion current in the depletion zone
decreases the drift current n the p side outside the depletion zone
decreases the drift current on the n side outside the depletion zone
does not change the current
nywhere ans: B

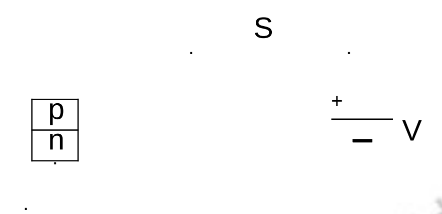
When a forward bias is applied to a p-n junction the concentration of electrons on the p side:

increases slightly
increases dramatically
decreases slightly
decreases dramatically
does not
change ans: B

Which of the following is NOT true when a back bias is applied to a p-n junction?

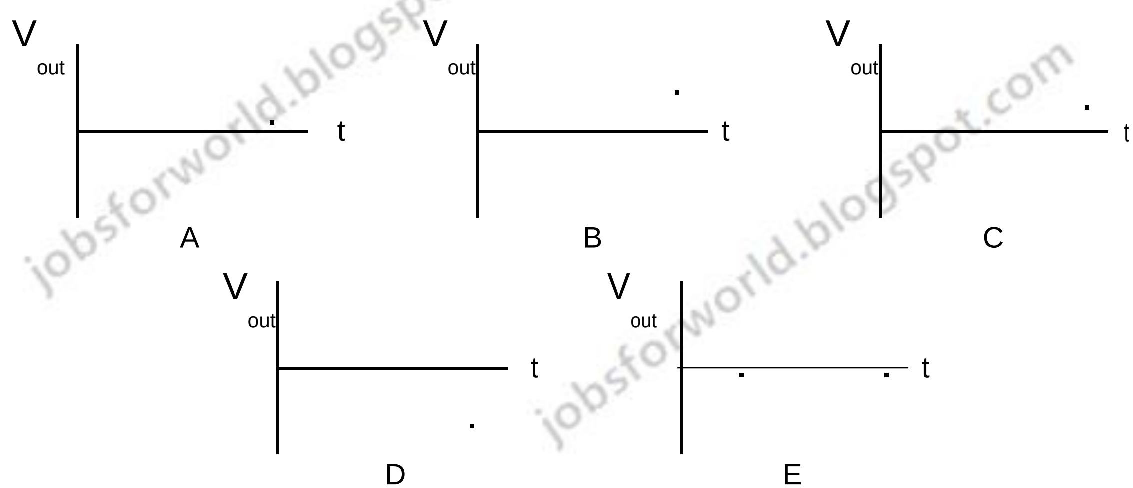
Electrons flow from the p to the n side
Holes flow from the p to the n side
The electric field in the depletion zone increases
The potential difference across the depletion zone increases
The depletion zone narrows ans: B

Switch S is closed to apply a potential difference V across a p-n junction as shown. Relative to the energy levels of the n-type material, with the switch open, the electron levels of the p-type material are:



unchanged
lowered by the amount $e^{-V e/kT}$
lowered by the amount $V e$
raised by the amount $e^{-V e/kT}$
raised by the amount $V e$ ans: C

A sinusoidal potential difference $V_{in} = V_m \sin(\omega t)$ is applied to the p-n junction as shown. Which graph correctly shows V_{out} as a fu ction of time?



ans: E

In normal operation the current in a MOSFIT device is controlled by changing:

the number of donors and acceptors
the width of the depletion zone
the size of the sample
the density of electron states
the temperature
ans: B

"LED" stands for:

Less Energy Donated
Light Energy Degrader
Luminescent Energy Developer
Laser Energy Detonator
none of the
above ans: E

A light emitting diode emits light when:

electrons are excited from the valence to the conduction band
electrons from the conduction band recombine with holes from the valence band
electrons collide with atoms
electrons are accelerated by the electric fi ld in the depletion region
the junction gets hot
ans: B

The gap between the valence and conduct on bands of a certain semiconductor is 0.85 eV. When this semiconductor is used to form a light emitting diode, the wavelength of the light emitted:

is in a range above 1.5×10^{-6} m
is in a range below 1.5×10^{-6} m
is always 1.5×10^{-6} m
is in a range centered on 1.5×10^{-6} m
has nothing to do with the g p
ans: B