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Q1:

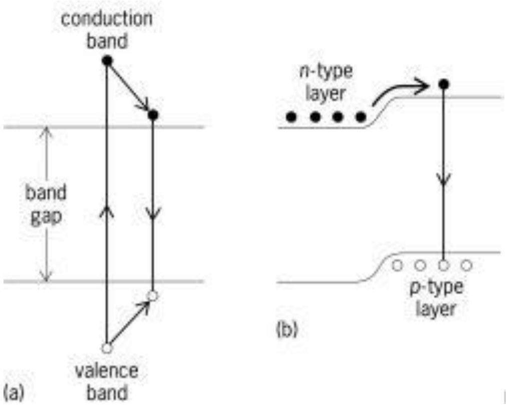
a. ***Explain the phenomena of electron hole pair recombination?***

electron-hole recombination

Electron-hole recombination

The process in which an electron, which has been excited from the valence band to the conduction band of a semiconductor, falls back into an empty state in the valence band, which is known as a hole. See Band theory of solids

Light with photon energies greater than the band gap can be absorbed by the crystal, exciting electrons from the filled valence band to the empty conduction band (illus. a). The state in which an electron is removed from the filled valence band is known as a hole. It is analogous to a bubble in a liquid. The hole can be thought of as being mobile and having positive charge. The excited electrons and holes rapidly lose energy (in about 10-12 s) by the excitation of lattice phonons (vibrational quanta). The excited electrons fall to near the bottom of the conduction band, and the holes rise to near the top of the valence band, and then on a much longer time scale (of 10-9 to 10-6 s) the electron drops across the energy gap into the empty state represented by the hole. This is known as electron-hole recombination. An energy approximately equal to the band gap is released in the process. Electron-hole recombination is radiative if the released energy is light and nonradiative if it is heat. See Phonon



Recombination of electrons and holes generated by (a) optical absorption and (b) a forward- biased pn junction

Electron-hole recombination requires an excited semiconductor in which both electrons and holes occupy the same volume of the crystal. This state can be produced by purely electrical means by forward-biasing a pn junction. The current passing through a pn diode in electrons per second equals the rate of electron-hole recombination (illus. b). A major application of this phenomenon is the light-emitting diode. See Light-emitting diode, Luminescence, Semiconductor diode

Efficient radiative recombination between free electrons and holes takes place only in direct-bandgap semiconductors. During an optical transition, momentum is conserved, and since the photon carries away negligible momentum, transitions take place only between conduction-band and valence-band states having the same momentum. This is easily satisfied in direct-bandgap semiconductors, because electrons and holes collect at the conduction band at minimum and the valence band at maximum, and both extrema have the same momentum. However, for indirect-bandgap semiconductors, the conduction-band minimum and valence-band maximum have very different momenta, and consequently optical transitions between free electrons and holes are forbidden. Radiative electron-hole recombination is possible in indirect-band-gap semiconductors when the transition is assisted by lattice phonons and impurities. See Crystal

Apart from its application in light-emitting diodes and laser operation, radiative recombination, especially at low temperatures (approximately 2 K or -456°F), has been a very important tool for studying the interaction of electrons and holes in semiconductor crystals. See Exciton

Competing with radiative recombination are the nonradiative recombination processes of multiphonon emission and Auger recombination. It is suspected that nonradiative recombination by multiphonon emission drives the movement of atoms at room temperature that are responsible for device degradation phenomena such as the climb of dislocations found in GaAs light-emitting diodes and lasers. Auger recombination has been shown to limit the performance of long-wavelength (1.3–1.6 micrometer) lasers and light-emitting diodes used in optical communication systems. See Auger effect, Laser, Semiconductor

b. ***What happens to the barrier potential when the temperature increases?***

The potential barrier is increased exponentially as the depletion region width is increasing as shown in Fig. 3. As the temperature increases, the value of the potential barrier is decreasing. The potential barrier has the highest value when temperature is at measure of the relative warmth or coolness of an object. Temperature is measured by means of a thermometer

or other instrument having a scale calibrated in units called degrees. The size of a degree depends on the particular temperature scale being used. A temperature scale is determined by choosing two reference temperatures and dividing the temperature difference between these two points into a certain number of degrees. The two reference temperatures used for most common scales are the melting point

of ice and the boiling point

of water. On the Celsius temperature scale

, or centigrade scale, the melting point is taken as 0°C; and the boiling point as 100°C;, and the difference between them is divided into 100 degrees. On the Fahrenheit temperature scale

, the melting point is taken as 32°F; and the boiling point as 212°F;, with the difference between them equal to 180 degrees. The Réaumur scale, used in some parts of Europe, also sets the melting point at zero, but it has an 80-degree temperature difference between 0°Re; and the boiling point at 80°Re;. The temperature of a substance does not measure its heat content but rather the average kinetic energy of its molecules resulting from their motions. A one-pound block of iron and a two-pound block of iron at the same temperature do not have the same heat content. Because they are at the same temperature the average kinetic energy of the molecules is the same; however, the two-pound block has more molecules than the one-pound block and thus has greater heat energy. A temperature scale can be defined theoretically for which zero degree corresponds to zero average kinetic energy see gas laws

Such a point is called absolute zero

and such a scale is known as an absolute temperature scale. The Kelvin temperature scale

is an absolute scale having degrees the same size as those of the Celsius temperature scale

the Rankine temperature scale

is an absolute scale having degrees the same size as those of the Fahrenheit temperature scale

. The relationship between absolute temperature and average molecular kinetic energy is one result of the kinetic-molecular theory of gases

. See heat

; thermodynamics

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Q2:

a. ***Explain the difference between majority and minority carriers? Explain the majority and minority carriers in n-type and P-type semiconductors?***

The charge carriers that are present in large quantity are called majority charge carriers. The majority charge carriers carry most of the electric charge or electric current in the semiconductor. Hence, majority charge carriers are mainly responsible for electric current flow in the semiconductor.

The charge carriers that are present in small quantity are called minority charge carriers. The minority charge carriers carry very small amount of electric charge or electric current in the semiconductor.

Charge carriers in intrinsic semiconductor

The semiconductors that are in pure form are called intrinsic semiconductors. In intrinsic semiconductor the total number of negative charge carriers (free electrons) is equal to the total number of positive charge carriers (holes or vacancy).

Total negative charge carriers = Total positive charge carriers

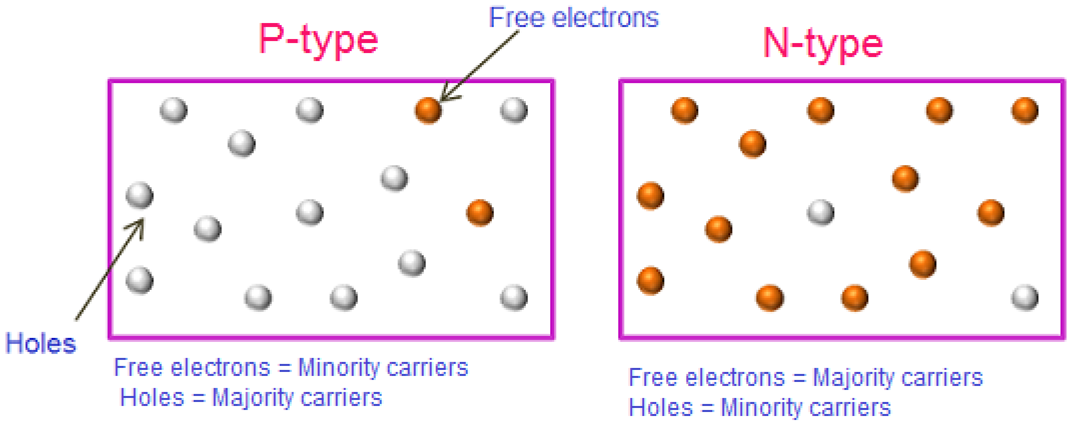
Majority and minority charge carriers in n-type semiconductor

When the pentavalent atoms such as Phosphorus or Arsenic are added to the intrinsic semiconductor, an n-type semiconductor is formed. In n-type semiconductor, large number of free electrons is present. Hence, free electrons are the majority charge carriers in the n-type semiconductor. The free electrons (majority charge carriers) carry most of the electric charge or electric current in the n-type semiconductor.

In n-type semiconductor, very small number of holes is present. Hence, holes are the minority charge carriers in the n-type semiconductor. The holes (minority charge carriers) carry only a small amount of electric charge or electric current in the n-type semiconductor.

The total number of negative charge carriers (free electrons) in n-type semiconductor is greater than the total number of positive charge carriers (holes) in the n-type semiconductor.

Total negative charge carriers > Total positive charge carriers



Free electrons = Minority carriers
Holes = Majority carriers

Free electrons = Majority carriers
Holes = Minority carriers

Majority and minority charge carriers in p-type semiconductor

When the trivalent atoms such as Boron or Gallium are added to the intrinsic semiconductor, a p-type semiconductor is formed. In p-type semiconductor, large number of holes is present. Hence, holes are the majority charge carriers in the p-type semiconductor. The holes (majority charge carriers) carry most of the electric charge or electric current in the p-type semiconductor.

In p-type semiconductor, very small number of free electrons is present. Hence, free electrons are the minority charge carriers in the p-type semiconductor. The free electrons (minority charge carriers) carry only a small amount of electric current in the p-type semiconductor.

The total number of negative charge carriers (free electrons) in p-type semiconductor is less than the total number of positive charge carriers (holes) in the p-type semiconductor.

Total negative charge carriers < Total positive charge carriers

b.When does reverse breakdown occur in a diode?

Break down" of a diode occurs during its reverse biased condition. We all know, under reverse bias the positive terminal of battery is connected to n side and the negative terminal of battery is connected to p side. ... At this point, the diode behave more like a shorted wire and hence current flows through it easily 300kg In semiconductor there is a layer near the p-n junction which is partially devoid of free charge carriers this layer is known depletion layer

Q3:

a. Find the difference between electric potential energy and electric potential?

The basic difference between electric potential and electric potential energy is that Electric potential at a point in an electric field is the amount of work done to bring the unit positive charge from infinity to that point, while electric potential energy is the energy that is needed to move a charge against the electric field.
The gravitational potential at a point in the gravitational field is the gravitational potential energy of a unit mass placed at that point. In this way, the electric potential at any point in the electric field is the electric potential energy of a unit positive charge at that point.
If W is the work done in moving a unit positive charge q from infinity to a certain point in the field, the electric potential V at this point is given by:

V = W/q

It implies that electric potential is measured relative to some reference point and like potential energy we can measure only the change in potential between two points.
Electric potential is the scalar quantity. Its unit is volt which is equal to joule per coulomb (J/C).
See Also: Types of charges

Definition of volt

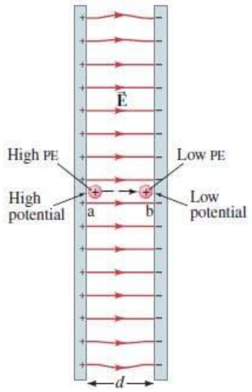
If one joule of work done against electric filed to bring the unit positive charge from infinity to the point in the electric field then potential difference at that point will be one volt.

Electric potential energy

To apply the law of conservation of energy, we need to define electric potential energy, potential energy can be defined only for conservative force. The work done by a conservative force in moving an object between any two positions is independent of the path taken. The electrostatic force between any two charges is conservative because the dependence of on positions is just like the gravitational force which is a conservative force. Hence we can define potential energy for electrostatic force.
We know that the change in potential energy between any two points, a and b equals the negative of work done by the conservative force on an object as it moves from point a to point b:

Δ P.E = -W

Hence we define the change in potential energy (**P.Eb – P.E a**), when a point charge q moves from some point a to another point b.As the negative of the work done by the electric force on charge as it moves from point a to b.
For Example, consider the electric field between two equally but oppositely charged parallel plates, we assume their separation is small compared to their width and height, so the field E will be uniform over most of the region as shown in the figure:



Work is done by the the electric field in moving the positive charge from position a to position b.

Now consider tiny positive charge q placed at point "a" very near to the positive plate. This charge q is so small that it has no effect on electric field E.If this charge q at point a is released, the electric force will do work on the charge and accelerate it towards the negative plate. Work done by the electric field E to move the charge at a distance d is

How to find the potential difference between any two points in the electric field lines?

In a uniform electric field, the equation to calculate the electric potential difference is super easy: **V = Ed**. In this equation, V is the potential difference in volts, E is the electric field strength (in newtons per coulomb), and d is the distance between the two points (in meters).Apr 21, 2015

What is Electric Potential Difference?

The electric potential at a particular point in space is the work done in moving a positive charge from infinity to that point. The electric potential at infinity is defined as zero. It is related to the electric potential energy in that electric potential is the electric potential energy per unit charge.

So, if a four coulomb charge has 4,000 Joules of electric potential energy due to its position in an electric field, that would mean that the electric potential at that point in the field is 1,000 Joules per coulomb - each coulomb has a thousand Joules of electric potential energy. Whereas electric potential energy is specific to a particular charge, electric potential is defined only by a position inside a field. This makes it a much more useful quantity.

To understand how a point can have potential at all, think about dropping a mass in a gravitational field. If you drop a ball, it falls to the ground. This is because it had gravitational potential energy relative to the ground, and this energy was released when you let go of the ball. Gravitational potential (instead of electric potential) would be the energy per unit mass (instead of energy per unit charge), and would describe the point in space where you let go of the ball.

Let's imagine we have two parallel plates: one with a positive charge and one with a negative charge. In electromagnetism, we use a positive charge to define electric fields. So we'll focus on what happens to a positive charge inside the plates. If you release a positive charge on the negative plate, it won't go anywhere because opposites attract. But, if you release it on the positive plate, it will follow the field lines and 'fall' to the negative plate. So when we talk about electric fields, we say that the field lines point in the direction of decreasing electric potential.

And now, finally, that brings us to electric potential difference. Electric potential difference is the difference in electric potential between two points in space. That's really all it is. It is also measured in Joules per coulomb, but this is usually shortened to a different unit: volts. The electric potential difference between two sides of a battery is what makes electricity flow around a circuit. A 12V battery, for example, has a difference in potential of 12 Joules per coulomb on the two sides of the battery.

Uniform Electric Field

In a uniform electric field, the equation to calculate the electric potential difference is super easy: **V = Ed**. In this equation, V is the potential difference in volts (or Joules per coulomb), E is the electric field strength in the area (in newtons per coulomb), and d is the distance between the two plates (in meters).

The parallel plates situation I mentioned earlier is an example of a uniform electric field. Between the plates the field lines are equally spaced, so the field has the same strength everywhere - it's uniform. If we wanted to figure out the potential difference between the plates, we could take the electric field between the plates, E, and just multiply it by the distance between the plates. Strictly speaking, this distance, d, should always be in the direction of the field lines (if you move left and right on this diagram, the electric potential doesn't actually change at all).