Semi-Conductors

Name:

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Course:

Date:

1. **What are semi-conductors? Give 2 Examples.**

Semi-Conductors are a class of solid substances intermediate in electrical conductivity between a conductor and an insulator. Semi-conductors are used in manufacture of various electronic devices like transistors and integrated circuits. Semiconductors make compact, reliable and power efficient devices. Semi-conductors have a wide range of current and voltage carrying abilities.

Examples of semi-conductors include; Carbon and Silicon.

1. **What is Fermi distribution?**

Fermi distribution is the probability of occupancy for an electron energy state at an energy level E by an electron. Fermi distribution is explained by the function;

F(E)=1/[1+exp((E-Ef))/ kT].

E is the electron Energy, Ef is the fermi energy and T is the absolute temperature. Different particles are distributed based on their fermi energy states at different levels. The fermi energy is the highest filled energy level as the system goes towards absolute zero.

1. **What are P-type and N-type Semi-conductors?**

P-type semi-conductors are those made by adding a trivalent impurity to an intrinsic semi-conductor. Trivalent impurity are group III elements with 3 valence electrons. P-type Semi-conductors have electrons as minority charge carriers and holes as majority carriers.

N-type semi-conductors are those made by adding a pentavalent impurity ton an intrinsic semi-conductor. Pentavalent impurity are group V elements with 5 valence electrons. N-type semi-conductors have electrons as majority carriers and holes as minority charge carriers.

1. **Explain the process of fabricating P-type and N-type semi-conductors.**

P-type semi-conductors are fabricated when an intrinsic semiconductor is doped by a trivalent impurity. For example, when a trivalent impurity is added to silicon which has 4 electrons, 3 valence electrons of silicon form covalent bonds with 3 valence electrons from the trivalent impurity leaving one electron hanging with a Hole. The Hole attracts electrons from then nearby silicon atoms, making the hole to keep changing as the nearby electrons keep being attracted to nearby holes hence creating conductivity. The Hole is considered to be of opposite charge to electron (Positive) hence the name P-type Semi-conductors

N-type semi-conductors are formed when a pentavalent impurity is added to an intrinsic semi-conductor like Silicon. For example, when a pentavalent impurity is added to silicon which has 4 valence electrons, 4 silicon electrons form covalent bonds with 4 electrons from the pentavalent impurity leaving one extra electron of the pentavalent impurity to move freely thereby being responsible for conductivity. The pentavalent impurity donates an extra electron to the intrinsic semi-conductor which is a negative electron hence the name N-type semi-conductor.

1. **What is a p-n junction?**

p-n junction is a boundary between P-type and N-type materials inside a semi-conductor. The p-n junction is formed by the process of doping. P-side of the boundary has excess holes while the N-side of the boundary has excess electrons. The P-side is therefore positively charged. The N-side is negatively charged.

1. **What is the difference between Photoelectric effect and Photovoltaic mechanism?**

Photoelectric effect involves light protons knocking electrons out of a material completely.

Photovoltaic effect involves protons from a light source knocking electrons only out of their orbits but the electrons are retained in the material. This allows the electrons to move freely throughout the material. Photoelectric and photovoltaic mechanisms are therefore the physical phenomenon responsible for creation of different electric voltage in a material when exposed to light.

1. **How batteries are different from Photovoltaic cells.**

While batteries store electricity directly, photovoltaic cells like solar cells do not store electricity directly.

Batteries can be separated from the source of electricity. However, photovoltaic cells like solar cells cannot be separated from the source of energy like sunlight.

Batteries can be used flexibly as they can be separated from source of electricity. But solar cells are less flexible as they cannot be separated from the source of energy.

1. **What are different technologies used to improve efficiency of photovoltaic cells?**

Leveraging intra-red technology for solar panels. Here cool solar panels can absorb cold on earth surface & generate electricity when there is no sun.

Perovskite cell added on top of a solar cell. Perovskite cell added on top of a solar cell increases energy absorption by 30%. The

Transparent solar technology. Transparent solar technology can replace traditional solar panels as residential and commercial building windows can be transformed into passive solar collectors to reduce overdependence on main electricity grid.

1. **What is a multi-junction cell? Explain efficiency of a cell is improved by this technology.**

A multi-junction cell is a solar cell with multiple p-n junctions made of different semi-conductor materials.

Efficiency of a multi-junction cell.

A multi-junction cell is more efficient since multi junction cells enhances cells absorption of sunlight and consequent conversion to electric energy. The p-n junction of each material will produce electric current based on different light wavelengths they are exposed to.

1. **What is Shockley-quesser limit**

Also known as detained balance limit. It is the maximum theoretical efficiency of a solar cell. Using a single p-n junction to collect power from the where the only loss mechanism is radiative combination in the solar cell. In 1961 William Shockley & Havs Joachim Quesser calculated the maximum theoretical solar cell limit using a primitive single p-n junction and found it to be 33%. Meaning that on a sunny day, a silicon solar cell with one p-n junction could collect up to 33% of suns ray.

1. **With a diagram, explain the process of solar-electricity generation in a p-n junction cell.**



Light travels in the marked packets of energy called photons and electricity generation happens inside the depletion zone of the PN junction. In the p-n junction, electrons from the N-type silicon diffuses into the holes of the P-type material. When a photon of light is absorbed by one of these atoms in the N-type silicon, it dislodges an electron creating a free electron and a hole which have enough energy to jump out of the depletion zone. A wire connected from N-type silicon (cathode) to P-type silicon (anode) allows electrons to flow through the wire. The electron is attracted to the positive charge of the P-type material and travels through the external load creating a flow of electric current hence solar electricity generation. The hole lefty by the dislodged electron attracts a negatively charged N-type material and moves back to electrical contact. The electron that was dislodged, enters the P-type silicon from the back electrical contact combining with the hole restoring the electrical neutrality.

1. **Explain the power-voltage characteristics of a typical solar cell.**

Short circuit current – When the load resistance is kept minimum, the maximum current flows in the circuit. When load is zero, maximum current is short circuit current.

Variation of I with V- As load resistance is increased, the voltage across the load resistance increases and current starts decreasing. When the load is maximum, the current is very small and the voltage across the load is maximum.

Open circuit voltage- when circuit is open, voltage is maximum and current is zero Voltage of a single photovoltaic cell is 0.5 volts with low output power. Connecting a number of cells together will form a system of solar panels of 12 volts or 24 volts.

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