1. What are semiconductors.

Semiconductors are materials that allow electric current to pass though them

Examples: silicon, gallium arsenide

2. What is Fermi distribution.

Is the description of how electrons are spread across different energy levels in a material at a certain temperature. It gives us the probability of an energy level having an electron in it by following two rules; electrons start filling the lower-energy levels first, and at absolute zero, all the low-energy seats are full and rest completely empty.

3. What is p-type and n-type semiconductors.

P-type and N-type semiconductors are materials whose electrical conductivity has been enhanced through doping, which involves adding specific impurities to the intrinsic (pure) semiconductor.

4. Explain a process for fabricating p-type and n-type semiconductors.

P-type fabrication.

Select a dopant element from Group 13 of the periodic table, e.g., boron, aluminum, or gallium due to the presence of three valence electrons.

Introduce the dopant into the silicon or germanium crystal using diffusion method where you heat the pure semiconductor and expose it to the dopant gas or vapor. The dopant creates holes (positive charge carriers) as it lacks sufficient electrons to complete bonds. These holes become the majority charge carriers, making the material p-type.

N-type fabrication.

Select a dopant element from Group 15 of the periodic table, e.g., phosphorus, arsenic, or antimony because they have five valence electrons. The semiconductor wafer is exposed to dopant gas (e.g., phosphorus oxychloride) at high temperatures in a furnace. The dopant atoms diffuse into the crystal lattice. The wafer is annealed (heated) to repair crystal damage and activate the dopants by integrating them into the lattice structure. The dopants provide free electrons (majority carriers), creating an n-type semiconductor.

5. What is p-n junction?

A p-n junction is the interface formed when a p-type semiconductor and an n-type semiconductor are joined together in a single crystal structure. Where the p-type is the positive side of the semiconductor, containing an excess of holes and n-type is the negative side of the semiconductor, containing an excess of electrons

6. What is the difference between photo electric effect and photo voltaic mechanism.

The photovoltaic effect is the process in which two dissimilar materials in close contact produce an electrical voltage when struck by light. This results in the creation of a voltage and an electric current in the material while the photoelectric effect is the emission of electrons from the surface of a substance in response to incident light. Incident light is the ray of light that strikes a surface. This occurs on metal surfaces.

7. How are batteries different from photo voltaic cells?
   Batteries produce electricity through a chemical reaction between metals and an electrolyte while Photo voltaic cells operate by generating current when light excites electron-hole pairs in semiconductors.
   Batteries store chemical energy and convert it into electrical energy through chemical reactions while photo voltaic cells convert light energy from the sun into electrical energy directly.
8. What are different technologies used for improving efficiency of a photo voltaic cells?
   Enhance light absorption by using advanced materials or antireflective coatings.
   Optimize electron-hole pair generation and collection through innovative designs.
   Reduce resistive losses by improving contacts and interfaces.
   Enhance overall system efficiency by incorporating maximum power point tracking (MPPT) and cooling mechanisms.
9. What is multi junction cell. Explain how the efficiency of a cell improved using this technique
   A multi-junction (MJ) solar cell is a solar cell made of multiple layers of different semiconductor materials, each with a different bandgap as this allows the cell to absorb a wider range of wavelengths of light, which improves its efficiency in converting sunlight into electricity
10. What is Shockley-quesser limit?
    The Shockley-Queisser limit (SQ limit) is the theoretical maximum efficiency of a solar cell that uses a single p-n junction to collect power. It represents the upper limit of power conversion efficiency for a solar cell, based on fundamental thermodynamic principles and material properties.
11. With a diagram explain the process of solar electricity generation in a p-n junction cell

Photon Absorption:

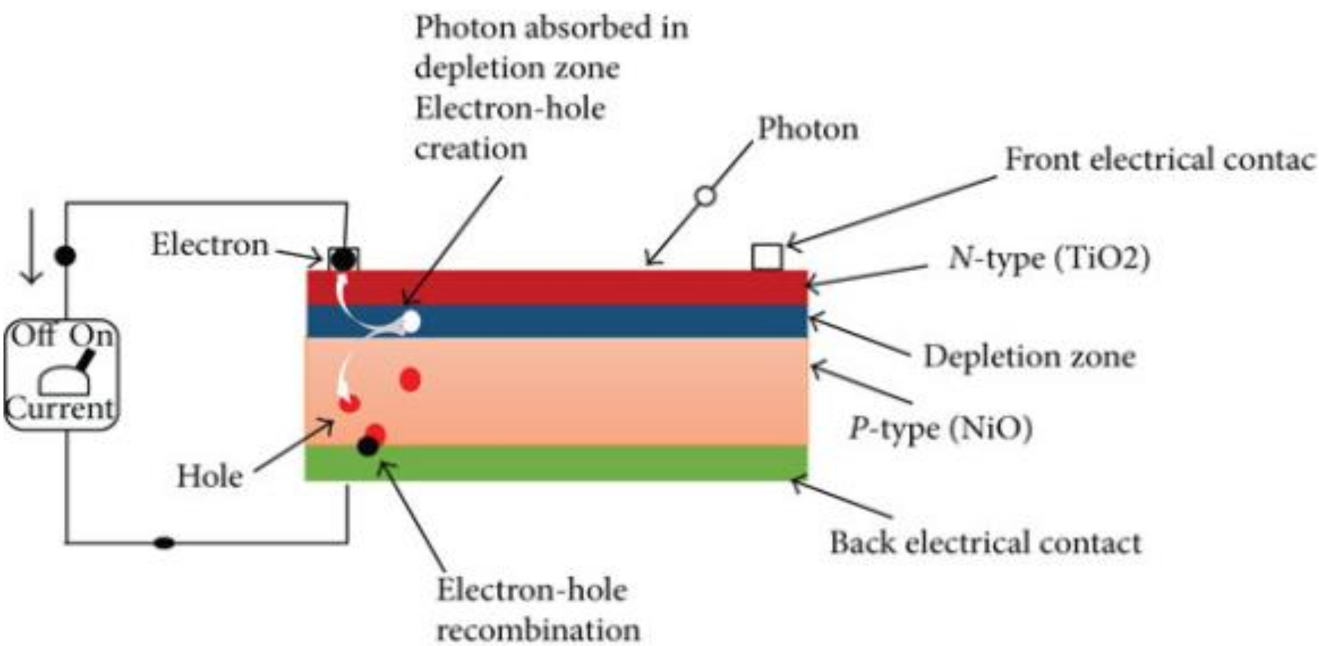
- Sunlight strikes the surface of the PV cell.
- Photons with energy equal to or greater than the bandgap of the semiconductor material (e.g., silicon) are absorbed.
- This energy excites electrons in the valence band, moving them into the conduction band, creating electron-hole pairs.

Separation of Charge Carriers:

- The electric field at the p-n junction (depletion region) drives the electrons toward the n-type region and the holes toward the p-type region.
- This movement ensures charge carriers do not recombine immediately and contributes to the current generation.

Electric Current Generation:

- Electrons collected in the n-type region and holes in the p-type region move toward their respective external circuit terminals.
- When connected to an external load, these charge carriers flow, producing an electric current.
- Continuous Process:
- As long as sunlight provides photons, electron-hole pairs are continuously generated, maintaining the electric current.



12. Explain the power and voltage characteristics of a typical solar cell.
 The performance of a solar cell is described by its current-voltage (I − V) and power-voltage (P − V).
 Characteristics:
 1) Open-Circuit Voltage (VOC **):**
 The maximum voltage the solar cell can produce when there is no current flowing (open circuit).
 Occurs when the load resistance is infinite.
 Primarily determined by the material and temperature of the solar cell.
 2) Short-Circuit Current (ISCI):
The maximum current the cell produces when the output terminals are shorted (voltage = 0).
Directly proportional to the intensity of the incident sunlight.
 3) Maximum Power Point (Pmax):
The point on the I−VI-VI−V curve where the product of current (III) and voltage (VVV) is maximized.

It corresponds to the optimum operating point for the solar cell, where it delivers maximum power to the load.

4) Fill Factor (FF):

A measure of the quality of the solar cell, defined as: $FF=Pmax/VOC \cdot ISCFF$

It represents the ratio of the actual maximum obtainable power to the theoretical power.

5) Efficiency (η):

    represents the fraction of incident light energy converted to electrical energy.
    $\eta=Pmax/\text{Incident Light Power}$

Higher efficiency cells produce more power for the same sunlight intensity