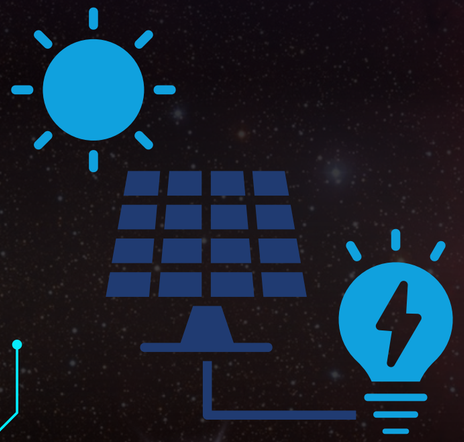
ENERGY CLUB
IIT BOMBAY

DAY 4

HOW A SOLAR CELL WORKS



TOPICS TO BE COVERED TODAY

- Understand how solar cells generate electricity from sunlight
- Grasp the idea of the photovoltaic effect
- Know what semiconductors and band gaps are
- See what a p-n junction is and why it’s used in solar cells

THE POWER OF THE SUN

DID YOU KNOW?

In just one hour, the sun gives Earth more energy than the world uses in a year

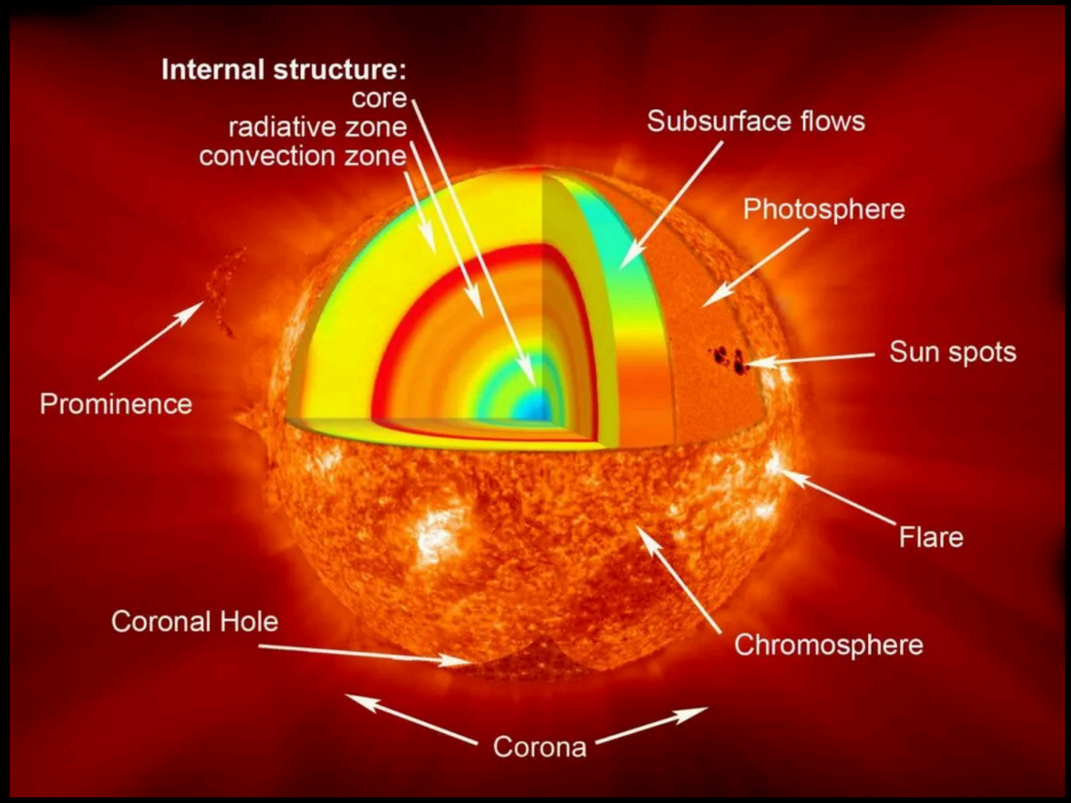
The sun is the ultimate source of energy for life on Earth

Sun is big ball of gas, mostly hydrogen where nuclear fusion reactions constantly release massive amounts of energy.

This energy travels through space as electromagnetic radiation including visible light, infrared and ultraviolet rays. A small fraction of this energy reaches Earth and powers everything with the help of solar.

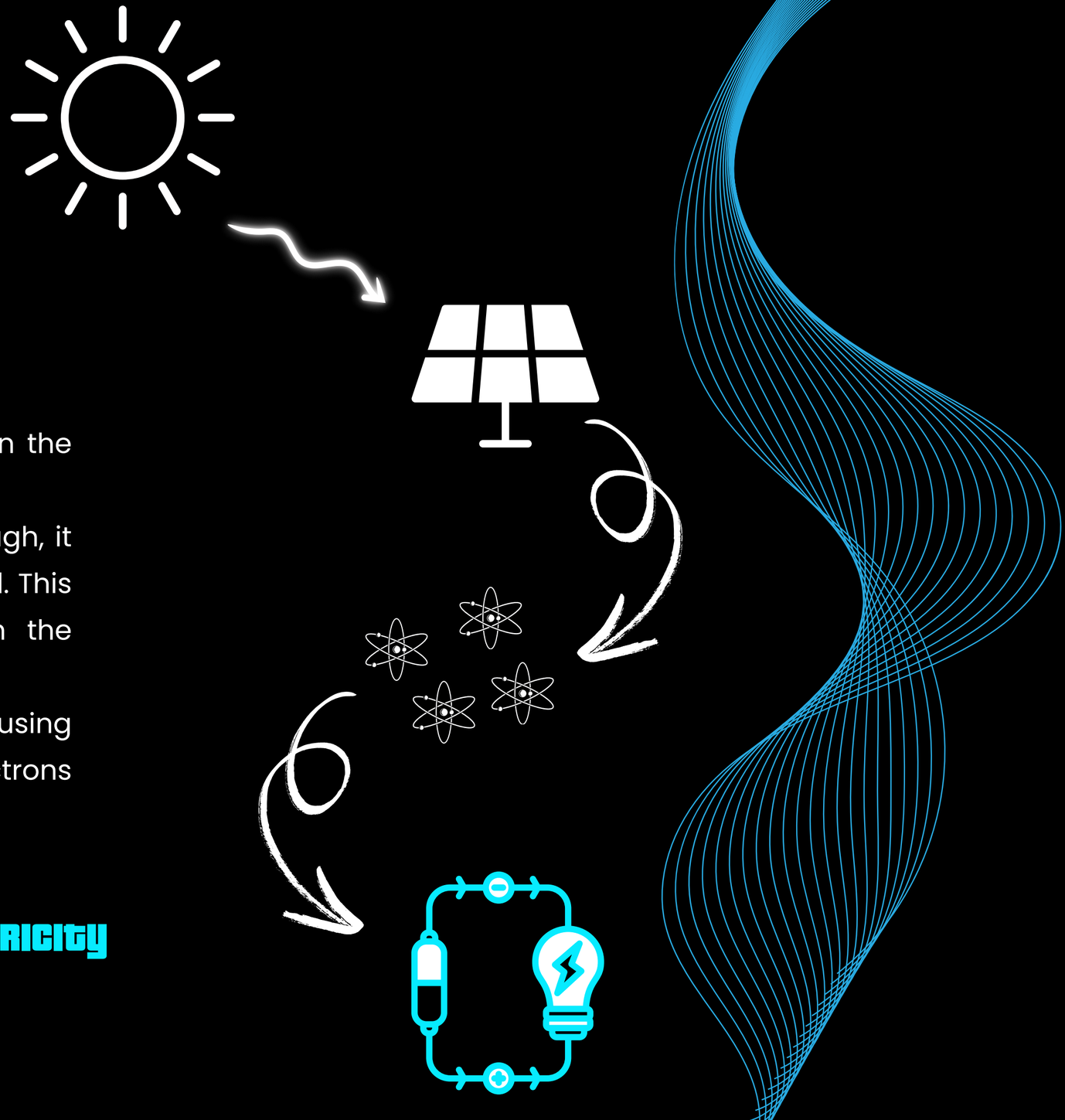
The solar constant i.e. the average solar power received just outside Earth's atmosphere is about 1361 watts per sq meter. But not all of this reaches the ground due to clouds, atmosphere and location on Earth.

This energy is what we aim to capture using solar cells.



1361 W/M SQ AS A SOLAR CONSTANT

WHAT IS THE PHOTOVOLTAIC EFFECT?



It happens in three simple steps:

1. **Light hits the solar cell:** The sunlight contains energy in the form of particles called photons.
2. **Electrons get excited:** If the energy of a photon is enough, it knocks an electron loose from its position in the material. This happens only if the photon has more energy than the material's band gap.
3. **Electricity is generated:** The solar cell is built in a way (using special materials like silicon) that pushes these free electrons in one direction creating an electric current.

Light → Excited electrons → Flow of electricity

SEMICONDUCTORS AND BAND GAP

Semiconductors are special materials. They're not full conductors like metals, and not full insulators either. That's what makes them perfect for solar cells.

The most common semiconductor used in solar panels is **silicon.**

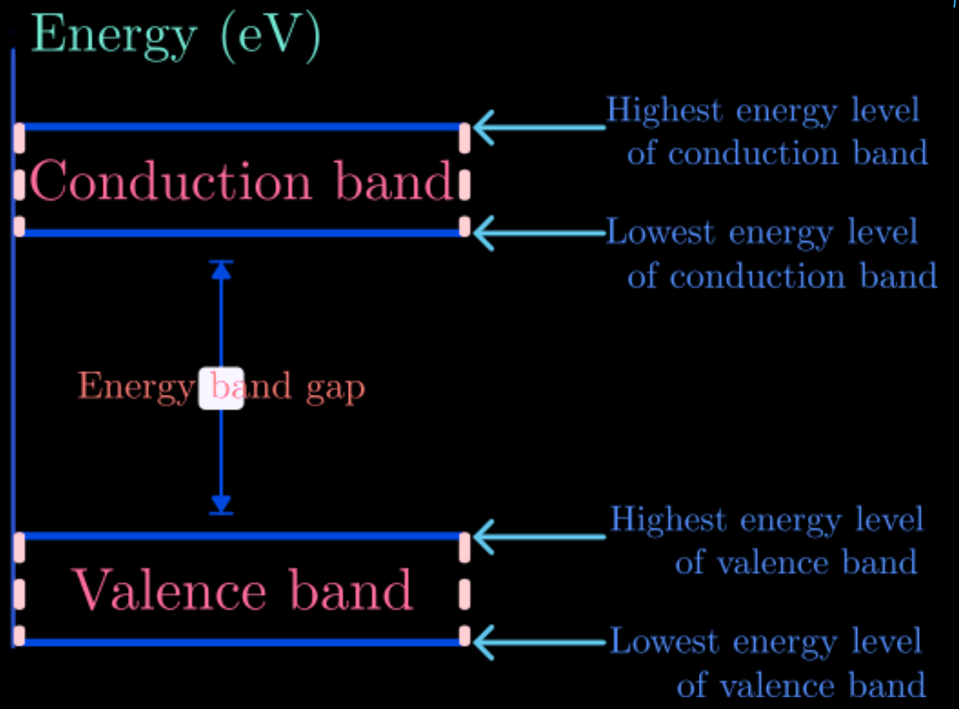
What makes semiconductors work in solar cells?

Every material has two main energy zones:

- The valence band: where electrons normally stay
- The conduction band: where electrons need to move and create electricity

The gap between these two bands is called the band gap.

If a photon has enough energy to cross this gap, it can excite an electron into the conduction band. That's how light becomes electricity. For example: Silicon's band gap is 1.12 electron volts (eV) — perfect for absorbing sunlight.



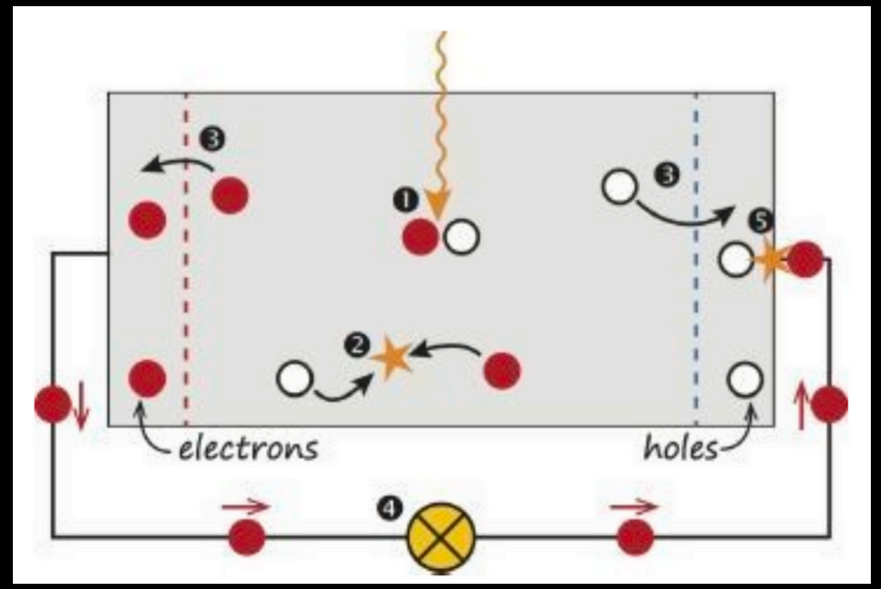
THE P-N JUNCTION

HEART OF A SOLAR CELL

A p-n junction is where two types of semiconductors, one with extra electrons (n-type) and one with missing electrons or “holes” (p-type) are joined together.

WHAT ?

1. Electrons from the n-side naturally want to move to the p-side.
2. Holes from the p-side move to the n-side.
3. This movement causes both regions to lose mobile charges.



This creates a region with no free charges called the depletion region which is like a barrier.
This region builds an electric field which:

- **Pushes electrons one way**
- **Pushes holes the other way**

This is what allows current to flow when light hits the solar cell!

So, the p-n junction acts like a gate, letting electricity flow in the right direction when the sun activates the system.

RECAP

The sun sends photons

These are tiny energy packets that travel from the sun to Earth as solar radiation.

The solar cell absorbs photons

If a photon’s energy is greater than the band gap of the semiconductor, it knocks an electron free.

The p-n junction creates an electric field

This field pushes electrons and holes in opposite directions.

Electrons flow through a wire which is electricity

The freed electrons flow out through an external circuit, powering whatever is connected be it a fan, light bulb, or your home.

It keeps happening as long as sunlight is there

The process is clean, silent, and keeps going.

Solar cells are built with just the right materials, designed to harness the physics of light and charge movement.

REVIEW QUESTIONS

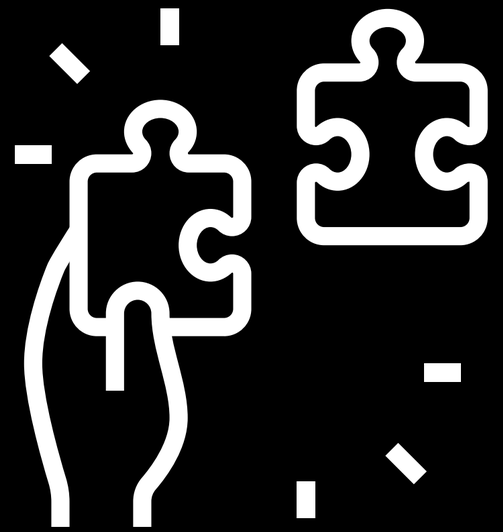
Ques 1. What is the primary mechanism by which solar cells generate electricity?

Ques 2. In a solar cell, what role does the p-n junction play?

Ques 3. What condition must be met for a photon to generate an electron-hole pair in a semiconductor?

Ques 4. What is meant by the ‘band gap’ in a semiconductor, and why is it important in a solar cell?

Ques 5. Briefly explain how the photovoltaic effect leads to electricity generation in a solar panel.



got any doubts regarding the course?

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