PN Junction Solar Cell – 16 Marks Answer

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1. Introduction

- A **solar cell** is a device that converts **sunlight into electricity** using the **photovoltaic effect**.
- A **PN junction solar cell** uses a **p-type and n-type semiconductor** joined together to form a **PN junction**.
- When sunlight hits the cell, it generates **electron-hole pairs** which produce **electric current**.

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2. Construction

- Made of **semiconductor material** like **Silicon (Si)**.
- Has two main layers:
    - **P-type layer**: Has **holes** (positive charge carriers).
    - **N-type layer**: Has **free electrons** (negative charge carriers).
- **Metal contacts** on both sides to collect and transmit current.
- **Anti-reflective coating** to absorb more sunlight.

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3. Working Principle (Photovoltaic Effect)

1. **Sunlight hits the PN junction**.
2. **Photons** (light particles) give energy to electrons in the **depletion region**.
3. This creates **electron-hole pairs**.
4. The **electric field** at the junction pushes:
    - Electrons to the **n-side**,
    - Holes to the **p-side**.
5. This movement generates **current** through the external circuit.

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5. Characteristics

- **Open-circuit voltage (Voc)**: Maximum voltage without current flow.
- **Short-circuit current (Isc)**: Maximum current when terminals are shorted.
- **Fill factor (FF)**: Quality of the solar cell.
- **Efficiency**: Ratio of electrical power output to solar power input.

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6. Applications

- **Solar panels** in homes, schools, industries.
- **Calculators and watches**.
- **Street lighting systems**.
- **Satellites and space vehicles**.
- **Solar power banks and chargers**.

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7. Advantages

- **Clean and green energy** – no pollution.
- **Renewable** – sunlight is freely available.
- **Low maintenance cost**.
- **Silent operation**.
- Can be used in **remote areas**.

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8. Disadvantages

- **Low efficiency** (~15–20% in common cells).
- **High initial cost**.
- **Depends on sunlight availability** (no power at night or cloudy weather).
- **Requires large space** for high power generation.

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9. Future Scope

- **Improved efficiency** with new materials (like perovskites).
- **Flexible solar cells** for wearable devices.
- **Transparent solar panels** for windows.
- **Better battery integration** for storage.
- Can help achieve **sustainable development goals**.

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10. Summary

- A **PN junction solar cell** converts light into electricity using a **semiconductor junction**.
- Works on the **photovoltaic effect**.
- Clean, renewable, and widely used in **modern energy systems**.
- Has great potential in the **future of green technology**.
