Incident Photon to Charge Carrier Efficiency of Solar Cells

$$\text{Quantum Yield} = \frac{\#\text{ of carriers, } n}{\#\text{ of photons, } N}$$

$$\phi = \frac{en}{eN} = \frac{en/s}{eN/s} = \frac{I(amp)}{eN/s}$$

$$\phi = \frac{I(amp)/cm^2}{\frac{eN}{s}/cm^2} \tag{1}$$

Incident Power:

$$P = Nh\nu$$

$$P\left(\frac{Watt}{cm^2} \text{ or } \frac{Joules}{sec\ cm^2}\right) = Nh\frac{c}{\lambda}$$

$$P\left(\frac{J}{s\ cm^2}\right) = \left(\frac{N}{s\ cm^2}\right)(6.62 \times 10^{-34} Js) \times \frac{3 \times 10^8 m/s}{\lambda(nm) \times 10^{-9} m}$$

$$\frac{N}{s\ cm^2} = \frac{P\left(\frac{J}{s\ cm^2} \text{ or } \frac{W}{cm^2}\right) \times \lambda(nm)}{(6.62 \times 10^{-17}) \times 3}$$

$$\frac{N}{s\ cm^2} = \frac{\text{Power}\left(\frac{W}{cm^2}\right) \times \lambda(nm) \times 10^{17}}{19.86} \tag{2}$$

Substituting the value of $\frac{N}{s\ cm^2}$ in eq. (1)

$$\begin{aligned}
\phi &= \frac{I_{sc}(amp/cm^2) \times 19.86}{e \times P(Watt/cm^2) \times \lambda(nm) \times 10^{17}} \\
&= \frac{I_{sc}(amp/cm^2) \times 19.86}{1.6 \times 10^{-19} \times P(Watt/cm^2) \times \lambda(nm) \times 10^{17}} \\
&= \frac{I_{sc}(amp/cm^2) \times 19.86}{P(Watt/cm^2) \times \lambda(nm) \times 1.6 \times 10^{-2}} \\
&= \frac{I_{sc}(amp/cm^2)}{P(Watt/cm^2)} \times \frac{1240}{\lambda(nm)}
\end{aligned}$$

$$\phi\% = IPCE\% = \frac{I_{sc}(amp/cm^2)}{P(Watt/cm^2)} \times \frac{1240}{\lambda(nm)} \times 100 \tag{3}$$

If the area of incident light is same for electrode and diode:

$$\boxed{IPCE\% = \frac{I_{sc}(A)}{P(W)} \times \frac{1240}{\lambda(nm)} \times 100}$$