

2015 PhD Quals Questions
J. S. Harris

1. Can you first tell me what a solar cell does and describe how it works?
2. Can you sketch the Current vs Voltage (I-V) characteristic for a solar cell under illumination?
3. On your sketch, what are the different parameters by which we characterize solar cells and what does each represent?
4. If I say that is the I-V characteristic for a Si solar cell with a 1.1eV bandgap, what would the characteristic look like for a GaAs solar cell with a 1.5eV bandgap?
5. What do you think is a typical range of solar cell efficiency? There is a now famous paper by Shockley and Queisser defining a limit efficiency for a solar cell. Why is there a “limit efficiency” and why is it so low? What happens to the energy that isn’t converted? Upon what parameter of the solar cell does the limit depend?
6. What strategy might you employ to overcome this limit and significantly increase solar cell efficiency?
7. Can you draw the energy band diagram for your solar cell at thermal equilibrium and then show me how you would modify that diagram to show what it looks like to describe the non-equilibrium situation when the cell is illuminated and first, in the short circuit current condition and explain? And second, what does the band diagram look like in the open circuit voltage condition and explain?
8. One of the proposed means to increase cell efficiency has been to create an intermediate band midgap level with quantum dots in a wider bandgap material such that we could use 2 IR photons with half of the bandgap that are otherwise not absorbed so do not contribute to the power generation to excite an electron first to the midgap level and then to the conduction band to produce an electron-hole pair in the wide bandgap material a higher V_{oc} . From 2 photons that are otherwise wasted. This looks good on paper, but has never worked. Can you guess what is the fundamental problem with this approach? (Hint—the lowest threshold, most efficient LEDs and semiconductor lasers are all based upon quantum dots)