Exercise 12.1: Exciton binding energy

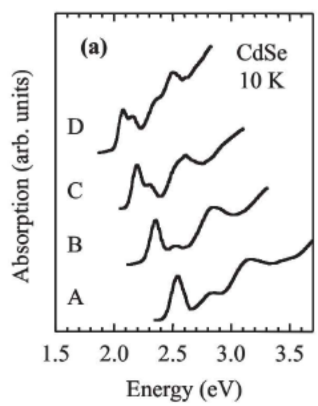
1) The inclusion of aluminum in GaAs increases the bandgap. In a GaAs/$Al_{0.3}Ga_{0.7}As$ quantum-well (QW), which semiconductor is used for the barriers and for the well?

2) The binding energy of the excitons in bulk GaAs and $Al_{0.3}Ga_{0.7}As$ are 4 meV and 6 meV, respectively. When the exciton's confinement is maximal, its binding energy is 17 meV. Discuss qualitatively how you would expect the exciton binding energy in such a QW to vary with the QW width. You can show a sketch of the binding energy as a function of the well width.

3) How does the exciton binding energy in quantum wells compare to the one in quantum dots?

Exercise 12.2: Absorption in quantum dots

1) From the absorption spectra, sort the following CdSe quantum dots A, B, C and D by increasing size.



2) Estimate the exciton binding energy for sample A, knowing the diameter d = 3.03 nm, the reduced mass $\mu = 0.1\ m_0$ ($m_0 = 9.11 \times 10^{-31}$ kg) and the bandgap of bulk CdSe (1.85 eV at 10K).

Exercise 12.3: Luminescence linewidth in QDs

How does the PL linewidth of a single QD compare to the one of the ensemble (consider an undoped sample)? What is the main factor ultimately defining the linewidth and which factors contribute to a larger linewidth? What is the effect of a metallic dopant such as copper on the PL linewidth?