

## PHAS0058 - Tutorial 2 questions

### Question 1.

Calculate total charge density in a graphene layer in which the optical absorption edge is shifted by  $\Delta E$ .

### Question 2.

One application of graphene is a transparent electrode. Consider an optoelectronic device with a graphene electron-injecting electrode into a material with HOMO 5.3 eV and LUMO 4.5 eV below vacuum level respectively.

- a) Draw energy diagram for the graphene/OSC device
- b) What carrier concentration is required to make this contact ohmic?

### Question 3.

Consider doped graphene spectrum in the far IR range. Assume that the doping level is  $5 \times 10^{11} \text{ cm}^{-2}$  and relaxation time 500 fs.

- a) What is the absorption of a single sheet of this material at 1THz?
- b) Compare your answer to absorption in pristine graphene and explain the difference.

### Question 4.

A graphene layer is to be used as a hole-injection contact in an organic light-emitting diode which has an emitter with a highest occupied molecular orbital lying 5.2 eV below the vacuum level. Assume the work function of pristine graphene to be  $\phi = 4.6 \text{ eV}$ .

- a) Determine the type of extrinsic doping and the carrier concentration (number density) of the graphene sheet that is necessary to make this hole-injecting contact ohmic.
- b) How could this doping level be measured? Include a relevant equation in your explanation.

### Question 5.

A core/shell structured Quantum Dot is synthesized with CdSe/ZnS composition.

- a) What should be the radius of the QD to achieve primary emission wavelength of 640 nm? Assume the bulk bandgap of CdSe is 1.74 eV and effective mass of an electron is  $0.13m_0$ .
- b) Describe qualitatively how would the energy levels and bandgap of the QD change if the shell was removed? Briefly justify your answer.