Name: ____________________________

Advanced Solid State Physics — Prof. Dr. W. Kuch
Winter semester 2014/2015
8th exercise sheet

Submission: Tuesday, 09. December 2014, before the lecture
(or drop until 10 o'clock of the same day in mailbox between rooms 1.2.38 and 1.2.40)

22. Carbon nanotubes (**) (4 points)

We consider a carbon nanotube with circumference vector (8,4) (see lecture notes for the definition). The distance between nearest-neighbor carbon atoms in graphene is 1.42 Å.

a) Calculate the circumference of this tube.
b) Sketch the reciprocal lattice and indicate the direction perpendicular to the tube axis and the Brillouin zone.
c) How long is (in k space) the distance between two nearest Γ points in this direction?
d) How many quantized states are between these two Γ points?

23. Electronic transitions between bands of nearly free electrons (**) (4 points)

Determine the absolute value of the wave vector in the reduced zone scheme ($k = 0 \ldots \frac{G}{2}$, where $\frac{G}{2} = \frac{\pi}{a}$) at which transitions of free electrons in a one-dimensional periodic crystal can be excited by absorption of a photon as a function of photon energy $\hbar\omega$ with a = 1.81 Å, E_F = 8.5 eV, and $\hbar\omega < 40$ eV. Which is the lowest possible photon energy for the excitation of such transitions? How would your result change if a more realistic dispersion of the bands close to the Brillouin zone boundary is assumed (nearly free electrons instead of free electrons)?

24. Photoemission from surface state (**) (4 points)

We consider again the surface state of Cu(111), which can be approximated by a parabola with $E = \frac{\hbar^2 k_{\|}^2}{2m^*} - E_0$, where E is measured relative to the Fermi energy, and $m^* = 0.45\ m_e$, $E_0 = 0.4$ eV. Up to which emission angle (defined with respect to the surface normal) can photoemission from this surface state be observed in a photoemission experiment using photons of $\hbar\omega = 16.85$ eV energy? Assume $\Phi = 4.5$ eV as work function of the detector.