NANO 705
Quiz 4

1) Please indicate answers by clearly *circling* the letter of your selection.

a) The ground-state energy of a particle in a 1-D box of size L is approximately:

$$\varepsilon_1 = \frac{m}{m_c} \cdot \left(\frac{10\text{ nm}}{L} \right)^2 \cdot (3.8\text{ meV})$$

Now assume a 3-D box of size $5\text{ nm} \times 5\text{ nm} \times 5\text{ nm}$. Using $m_c = (0.1) \cdot m$, estimate the ground-state energy.

i) 0.0456 eV
ii) 0.114 eV
iii) 0.511 eV
iv) 0.152 eV
v) 11.4 meV
vi) 0.0259 eV
vii) 0.456 eV
viii) none of the above

b) The 1-D dispersion relation for electrons in a band is given by:

$$E(k) = \frac{\hbar^2}{2m} \cdot \left(3 + 4k^2\right)^2$$

Find the effective mass for electron in the band.

i) $m/4$
ii) $m/12$
iii) $m/3$
iv) m
v) $m/24$
vi) $m/6$
vii) $m/7$
viii) none of the above

2) Identify the following statements as true or false (T/F):
Additional justification may be added to clarify your answers.

a) ___ All of the outer-shell electrons of carbon atoms in graphene are used to form sp^2 among neighboring atoms, so there are no electrons available for electrical conduction without additional doping.

b) ___ Near the reciprocal-space point $\left(0, 2\pi/3b\right)$ for graphene, the kinetic energy of electrons varies as $\hbar^2 k^2 / 2m^*$, where k is the reciprocal-space distance from this point and m^* is the effective mass.

c) ___ The density of states for a quantum dot consists of discrete delta functions in energy.

d) ___ A quantum wire can never form subbands, since there is no electron confinement along the wire axis.

e) ___ All armchair carbon nanotubes are metallic ($E_g = 0$).

f) ___ The bandgap of semiconducting, zig-zag nanotubes increases with increasing diameter d.