Concept questions – FSK 324 chapter 5 2013

1. Discuss the symmetry properties of the energy bands $\varepsilon_n(\bar{k})$. Make use of diagrams in your discussion and identify at least the first two Brillouin zones in the diagrams. (5)

2. The binding energies of the core level electrons in the atom can be determined by a technique called X-ray photoelectron spectroscopy (XPS). Discuss the principles of this technique. (5)

3. Consider a linear lattice with lattice parameter *a* and a weak harmonic potential of the form $U = U_0 + U_1 \cos\frac{2\pi x}{a}$. When the wave vector (*k*) of the free electron has the value π/a, the wave function is a linear combination of forward and back scattered waves.

$$\psi_{\pm} = C(e^{ikx} \pm e^{-ikx})$$

Explain how this leads to an energy gap at the boundary of the first Brillouin zone. (5)

4. Briefly discuss the behaviour of the electrical conductivity in (i) metals, (ii) semi conductors and (iii) semi metals. Make use of simple energy vs. wave vector (*k)* diagrams to support your answer. (5)

5. The behaviour of an electron in a crystalline material can be determined by studying the Schrödinger equation, namely

$$\left[-\frac{\hbar^2}{2m}\nabla^2 + V(\bar{r})\right]\Psi(\bar{r}) = \varepsilon\Psi(\bar{r})$$

$V(\bar{r})$ is periodic and has the same translation symmetry as the lattice. Write down the Bloch solution to this equation and discuss the properties of the Bloch function. (5)