Level 3 Condensed Matter Physics- Part II
Weekly problem 1 solutions

(1) The lattice constant for InP is 5.87 Å. We want to find x such that $a(Ga_xIn_{1-x}As)$ = 5.87 Å.

$$a(Ga_xIn_{1-x}As) = xa(GaAs) + (1-x)a(InAs)$$
$$5.87\text{ Å} = x5.65\text{Å} + (1-x)6.06\text{Å}$$
$$x = 0.46$$

[2 marks]

The energy gap at this composition is:

$$E_g(Ga_xIn_{1-x}As) = xE_g\ (GaAs) + (1-x)E_g(InAs)\ -bx(1-x)$$
$$= 0.73\text{ eV}$$

[2 marks]

(2) We first express the energy of the conduction electron in the following manner:

$$E(k_x,k_y) = (A+B)k_x^2 + Ak_y^2$$

From the definition of the effective mass tensor $(m^*)_{ij} = \hbar^2/(d^2E/dk_idk_j)$ it follows that:

$$(m^*)_{xx} = \hbar^2/2(A+B)$$

[2 marks]

$$(m^*)_{yy} = \hbar^2/2A$$

[2 marks]

(3) The fractional atom coordinates for a fcc lattice is [0,0,0], [½,½,0], [½,0,½] and [0,½,½]. Adding the [¼,¼,¼] vector gives the other four atom positions, i.e. [¼,¼,¼], [¾,¾,¼], [¾,¼,¾] and [¼,¾,¾].

[2 marks]