**UConn** **ECE4211 HW#2** 01/24/2017, Due 01/31/17, F. Jain,NAME\_\_\_\_\_\_\_\_\_

 **Popquiz#1** on 1/31/17

Q.1. If the Schrodinger equation is solved for an atomic chain of length L (Fig. 7) but with finite potential barrier (unlike Q. 10 where it is infinite), the electron energy as a funciton of momentum or wave vector is shown in Fig. 8.



Fig. 7 [Fig. 22 notes] . Potential in Kronig-Penney model.

We get a solution of electron energy E as a function of k (the momentum vector) of the form shown below.



Fig. 8 Energy E- wavevector k (related to momentum) diagaram [Fig. 24b Notes].

(a) what is the minimum unit of momentum or wave vector k (Fig. 8) for a cube of L? **Circle one**: h//L h/2L

HINT: momentum p=(h/2k=h/, as k=2/; /2=L for a chain of L atoms.

(b) will momentum be **smaller** or **higher** if the length of chain is doubled to 2L. **Circle one. h/4L h/2L**

(c) does the interatmic separation and lattice constant ‘a’ determine the forbidden gap Eg. **Circle one Yes** **No**

Q.2. Si is available in Single Crystalline, poly Crystalline, and amorphous forms.

(a) Is the energy band gap same for crystalline and poly-crystalline? **Circle one**

 YES NO

(b) Is the energy band gap of crystalline and amorphous Si same? **Circle one**

 YES NO

Q.3 If energy density of states in conduction and valence band are known, and Fermi-Dirac distribution f(E) is known. Conduction band density of states N(E) = and 

(a) What is the expression of concentration of electrons in conduction band? HINT-p 38 Notes.

 n=

(b) If the hole concentration is  (77), what is the significance of term [1-f(E)]

(c) Write the expression for majority hole concentration in the valence band. p=

Q.4(a) . Pick the charge neutrality equation for n-Si. **Circle one**

Q.4(b) How would you calculate Fermi level Ef in n-Si.

Q4(c) How do we calculate Fermi level Ef in p-Si.

Q.5(a) Figure below shows three Fermi level locations. Label them as n-type, p-type, and intrinsic.

$Type equation here.$

 Q.5(b) **Circle** the energy band diagram which represents the donor energy level ED with respect to Conduction band edge EC (left side).

Q. 5(c) Circle the B and acceptor leverl with respect to VB.



Q6. Charge neutrality condition in an n-p junction is . Assume ND+~ND and NA-~NA.

 (a) Derive expressions for xn0 and xp0 in terms ofdoping if the junction width Wo = xno +xpo,.

 xn0 =

 xp0 =

(b) If n-type side is more heavily doped with donor atoms than the conctratoin of acceptors on p-side, the magnitude of xn0 will be higher than xp0. **Circle one**

 TRUE FALSE

Q7. Gauss’ Law states that the net outflow of displacement flux $\vec{D}$ intersecting a closed surface enclosing charge is equal to the enclosed charge density . Poisson’s equation is expressed in terms of displacement vector D and charge density : $∇∙\vec{D}$ = , and .

(a) Write Gauss’ law in terms of potential V. HINT: D =r o E and E = -$∇$V.

(b) Label the charge density plots of Figs. 1 and 2 as either p-n or n-p junction. Here, p(x) and n(x) are neglected in the junction.

|  |  |
| --- | --- |
| Fig. 1 **Circle one**: p-n OR n-p | Fig. 2 **Circle one**: p-n OR n-p |

Q8. (a) Write the expression for electric field $\vec{E}$ using Poisson’s equation Q5 (a)

E=

 (b) Plot the electric field E for the above two $ρ$ plots in Fig. 3a and 3b.

|  |  |
| --- | --- |
|  |  |

Fig. 3(a) E-field plot for Fig. 1 Fig. 3(b) E-field plot for Fig. 2.

 Q9. (a) Draw the energy band diagram for n-p junction under equilibrium and under forward bias.

Equilibrium Forward bias

(b) The band bending or built-in voltage Vbi is given by: **CIRCLE ONE**



 OR

Q10. (a) The relationship between hole concentration p(-xpo) on p-side at the junction boundary -xpo and hole concentration p(xno) on n-side are related at equilibrium is expressed by

 p(-xpo)/ p(xno) = ?

(b) Under forward bias the relationship is: **complete the equation**

 p(-xp)/ p(xn) = p(-xpf)/ p(xnf) = ?

(c) Under reverse bias: complete the equation

 p(-xpr)/ p(xnr) = ?

Q11. Find the coefficient A and B for a p-n junction diode shown in Fig. 4 with a finite neutral n-region ln.

 Fig. 4

Carrier distribution equation (53A) 



Boundary conditions (BCs) are:

 OR

 (BC#1) , and BC#2 .

Here, ln is the length of n-region. The n-region is finite ln (not ∞).

HINT: BC#1 gives , and BC#2 gives . Find A, B.

Q12. (a)Expression of junction capacitance under equilibrium (Wo) , forward bias (Wf) and reveres bias Wr.

12(b)Write expressions for diffusion capacitance Cdiff under forward bias.