NAME: EP

20/

ECE609 Semiconductor Devices
Spring 2009

QUIZ-1

2

Question 1
If the photoelectric effect were governed by classical physics rather than quantum mechanics, what would happen in the experiments below:

a- By changing the frequency of the incident radiation, what would happen to the energy of the extracted electrons ?

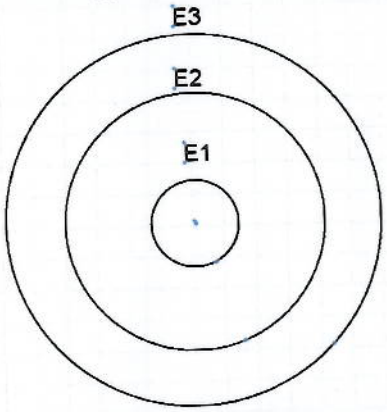
1 nothing

b- How about changing the intensity of the light ?

1 the energy of the e^- will change as well.

2

Question 2
Consider the first three energy levels of the Hydrogen atom below:



E1=-13.6eV
E2=-3.4eV
E3=-1.5eV

a- Starting at equilibrium, what would happen if an incoming photon hits the atom with energy +14ev ?

1 e^- will leave the atom → ionization H^+

b- suppose instead that a photon with energy +12.1eV hits the atom, can you describe what could happen afterwards ?

0.5 the e^- make then a transition from E_1 to E_3.
After that it will come back to equilibrium either by:
0.5 (i) emitting a photon of energy 12.1eV (E_3-E_1)
Bonus 0.5 (ii) // 2 photons with energy (E_3-E_2) and (E_2-E_1)

0.5

Question 3
What does the formula $p=\hbar k$ mean ?
Circle one choice below:

Dispersion relation

Pauli-exclusion principle

duality wave-particle

quantization of the electromagnetic radiation

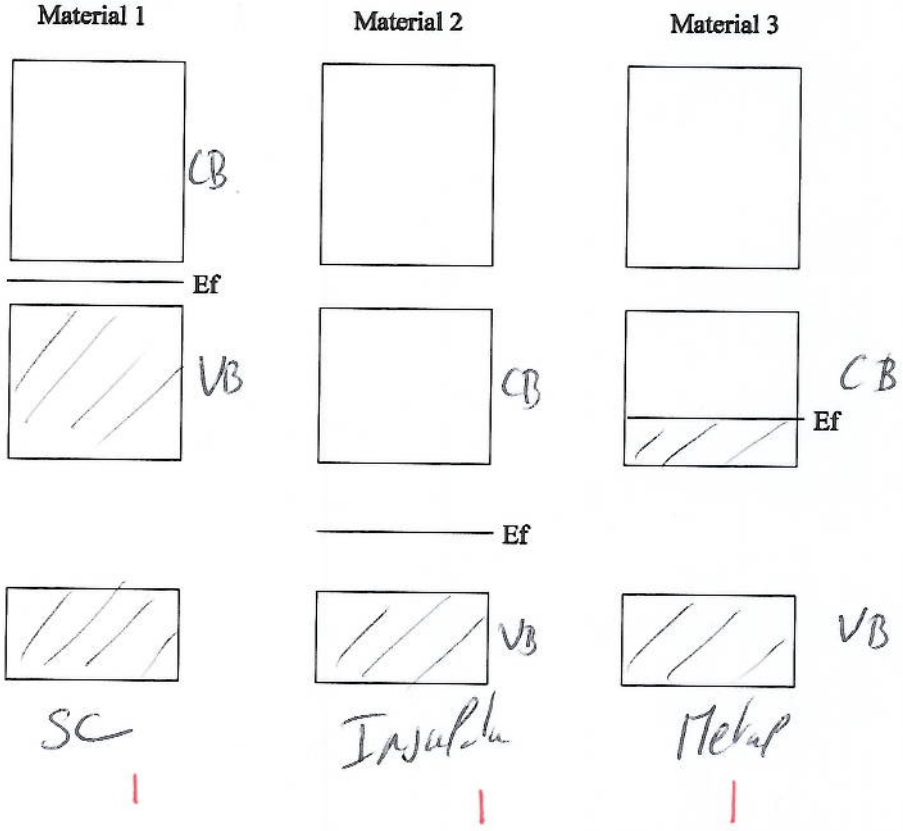
1.5

Question 4
Associate (a) (b) (c) with one of the proposition (1), (2), or (3) for the resulting energy spectrum.
(a) free electron, (b) crystal, (c) single atom
(1) discrete, (2) continuum, (3) energy band

a-2 0.5
b-3 0.5
c-1 0.5

3

Question 5
The following three diagrams show three different energy band diagrams of some hypothetical crystalline materials. The only difference between the three materials is the assumed Fermi level energy E_F. Characterize each material as a **metal**, **insulator** or **semiconductor.** You will also specify **valence band (VB)** and **conduction band (CB).**



1 1 1

Question 6

Let us consider **a semiconductor** material, are the following definitions for the Fermi level E_F **True or False** ?

Circle one choice below:

a- At T=0, it is the maximum energy level that can take an electron

True – False

b-At T=0, it is an energy level that lies between VB and CB

True – False

c-At T=0, all the energy levels below E_F will be occupied

True – False

d-At T>0, there will be 50% of chance to find an electron at E_F

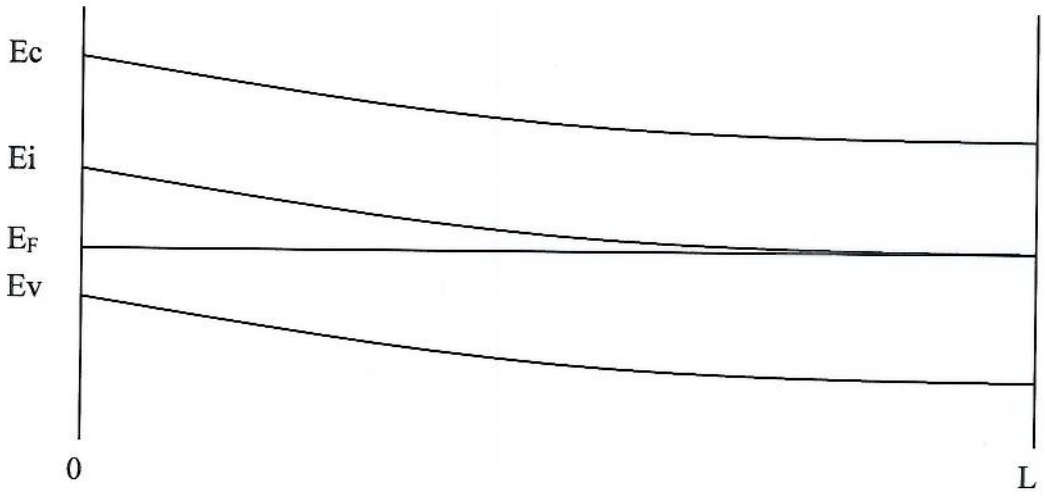
True – False

Among the definitions a, b, c, d, which one is the most general definition of the Fermi level (for any type of materials or systems)?

c

Question 7

A silicon device maintained at 300*K* is characterized by the following energy band diagram from x=0 to x=L:



Circle one choice below for each question below::

a- The hole concentration is higher in x=0 than in x=L

True – False

b- It is a non-uniformly doped semiconductors with donors

True – False

c- It is a non-uniformly doped semiconductors with acceptors

True – False

d- It is a uniformly doped P-type semiconductor

True – False

e- the semiconductor material is in equilibrium

True – False

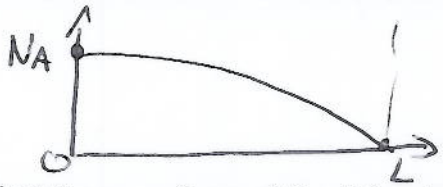
f- n=ni in x=L

True – False

g- $n=ni^2/p$ in x=L/2

True – False

From 0 to L, plot the doping profile for this semiconductor.



4

Question 8- Jeopardy: Find the questions of the following 8 answers:

Example: answer - it is the sun

Question –What is bright and high in the sky ?

1- It is a pure semiconductor

What is an intrinsic SC ?

2-It is the probability that an allowed energy E, will be occupied by a hole.

What is 1-f ?

3-Electron can then jump from the valence band to the conduction band

What happen if one increases the temperature in SC?

4-It has intentionally added dopants to control the number of charge carriers

What is an extrinsic SC ?

5-It is an insulator with a very narrow bandgap

what is a SC ?

6-At finite temperature, it is a conductor with very large resistivity

What is a SC?

7-Because we want to increase the electron concentration

Why does one dope SC with donors atoms ?

8-Because we want to increase the hole concentration

// // // // acceptors atoms ?