Materials Science on CD-ROM

AN INTERACTIVE LEARNING TOOL FOR STUDENTS

Version 1.1

SOLUTIONS MANUAL

Additional Questions with Suggested Answers

PWS PUBLISHING COMPANY
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7.	In the simulation photons are only emitted in two directions. In practice a photon should be emitted isotropically (equally in all directions). In which direction should the laser beam form?	In the plane of the well, photons travelling perpendicular to the well are quickly lost and are not effective in stimulating emission. In practice the laser beam is confined to a pseudo-one-dimensional strip by the manufacturing geometry of the device.

DENSITY OF STATES

Effective Mass Page D:2

8.	If the energy-momentum relationships are parabolas of the form given in the text, why do they not go through the origin?	The choice of an origin for the energy axis is essentially arbitrary. There are many ways of thinking about the difference in energy between an electron and a hole. In a semiconductor it is perhaps simplest to consider the two curves as being separated by the band gap, with the intrinsic Fermi level at the origin shown here.

Ideal Density of States Curve Page D:7

9.	Click on the region of the diagram which corresponds to the empty states below E_f.	Response is shown on screen
10.	Now click on the region which shows the extra states above E_f.	Response is shown on screen

Effect of Diffraction Page D:8

11.	The diagram initially shows the Fermi sphere within the first zone when there is less than 1 electron per atom (e/a = 0.4). Try increasing the number of electrons per atom (this is rather like alloying two elements of different valency). Watch what happens to the Fermi sphere and deduce at what level of e/a electrons start to fill the second zone.	Overlap is visible in this diagram when e/a = 2.2 (i.e. more than 2) when the band gap is large, but at 1.8 (i.e. before the first zone is full) when the band gap is small.

Real Density of State Curves Page D:11

12.	Why does the γ-brass parabola deviate upwards at around e/a = 1.5?	Because the Fermi sphere begins to distort when it approaches a Brillouin zone boundary
13.	Over what range can you change e/a for γ-brass? How?	The composition range for γ-brass is 60-70at% Zn. Assigning a valency of 2 to Zn and 1 to Cu, this implies an e/a range of 1.6 to 1.7
14.	The chromium DOS curve cannot be constructed from five parabolas, one for each sub-band. What further effect needs to be invoked to explain its complex shape?	Hybridisation among the five 3d sub-orbitals.

CONDUCTION

Introduction Page C:1

15.	What limits the number of electrons available for conduction in an n-type semiconductor at room temperature?	The temperature (limiting the number of electrons which can be thermally promoted to the conduction band) and the dopant concentration (limiting the total number of electrons available).

Thermal Motion and Drift Velocity Page C:2

16.	Calculate the thermal velocity of a Fermi level electron in aluminium, given that the Fermi energy is 11.4eV.	Using $E = mv^2/2$, With $m = 0.911 \times 10^{-30}$kg and $1eV = 1.602 \times 10^{-19}$J gives $v = 2 \times 10^6$ m/s.