Vasavi College of Engineering (A)

Subject: Semiconductor Physics and Optoelectronic Devices (2021-22)-I SEM

Unit: I [Fundamentals of crystallography]

Numericals:

1. A beam of x -rays emitted from the opening of a electron gun is diffracted by the (111) planes of a nickel crystal at angle of $28^{o}\,30^{1}$ .Calculate the wavelength of X-rays for first order. Nickel has FCC structure and its lattice parameter is $3.52A^{o}$.

2. Calculate the glancing angle of (111) plane of a cubic crystal having axial length 0.19nm corresponding to the second order diffraction maximum for the X-rays of wavelength 0.058nm.

3. A beam of X-rays incident on a sodium chloride crystal (lattice spacing 0.282nm).The first order Bragg reflection is observed at a glancing angle of $8^{o}\,35`$. What is the wavelength? At what angles would the second order Bragg's reflections occur? (3M)

4. In a tetragonal lattice a=b=0.18nm, c = 0.25nm, deduce the spacing between (111) planes

5. Determine the miller indices of a plane parallel to y-axis cutting intercepts along 2a, 3c/4 along the x & z axes, respectively.
6. The density of copper is 8.96 gm/cm^3 and Avogadro number is 6.02×10^{23} gm-molecule. The atomic weight of Cu is 63.5. Find the lattice constant for copper and the distance in Armstrong units between the two nearest Cu atoms in FCC lattice.

7. In a crystal whose primitives are $1.2A^{o}$,$1.8A^{o}$ and $2.0A^{o}$ a plane (2 3 1) cuts an intercept $1.2A^{o}$ on X-axis. Find the corresponding intercepts on Y & Z axis.

Unit: 2: Introduction to Quantum Mechanics and Solid State Physics

Numericals:

8. A particle is moving in a one – dimensional potential box of infinite height of width 2.5nm. Calculate the probability of finding the particle within an interval 0.5nm at the centre of the box when it is in its state of least energy.
9. Electrons are accelerated by 400 volts and are reflected from a crystal. The first reflection maximum occurs when the glancing angle is 60^{o}. Determine the spacing of the crystal.
10. Calculate the ratio of de-Broglie wave lengths of a helium molecule confined in a gas chamber at two different temperatures $27^{o}C$ and $200^{o}C$.
11. An electron has a speed of 5.00×10^{3}m/s with an accuracy of 0.003%. Calculate the certainty with which we can locate the position of the electron. Given that $h=6.626 \times 10^{-34}$J-s, $m=9.1 \times 10^{-31}$kg

12. Calculate the energy difference between the ground state and third excited state of an electron in a I-D rigid box of length 10^{-8}cm.
13. Find the de-Broglie wavelength of a neutron having kinetic energy 1eV.(2M)
14. Calculate the de-Broglie wavelength of an α-particle accelerated through a potential difference of 5000V.

Unit: 3: Semiconductor Physics

Numericals:

15. A Sample of intrinsic germanium has μ_e=0.38m^2 /V-S, μ_h=0.17m^2 /V-S respectively. If the density of electrons and holes are each equal to 2.8x10^{18} /m^3. Find electrical conductivity and resistivity of the sample.
16. Calculate the intrinsic carrier concentration, intrinsic conductivity and resistivity of Ge at 300K using the following data: μ_e=0.36m^2 /V-S , μ_h=0.18m^2 /V-S, E_g = 0.7eV, m_e * =0.55m_o and m_h * =0.37m_o
17. The conductivity of Germanium at 20^{o}C is 2 Ω^{-1}-m^{-1}, what is its conductivity at 40^{o}C? E_g=0.72eV.
18. In a slab of width 5mm, electrons have drift velocity of 4x10^3 m/s under the influence of an applied electric field along the X-axis. Calculate the hall voltage if the specimen is subjected to a magnetic field of 4Wb/m^2 along Z-axis.
19. A current of 50A is established in a cu slab (0.2 cm thick, 2 cm wide). The slab is placed in a magnetic field B of 1.5T along z- axis. The free electron concentration in cu is 6.8 x10^{28}/m^3. What will the magnitude of hall voltage across the width of the slab?
20. The R_H of the specimen is 3.66x10^{-4} m^3/C. Its resistivity is 8.93x10^{-3} Ω-m. Find μ and n.

Unit: IV: Optoelectronic Devices

Numericals:

21. An LED made of GaAs radiates a light of wavelength 880nm, If the forward current is 50mA calculate the power output if the internal quantum efficiency is 5%.
22. Calculate optical power output from LED with an electron current of 2.0mA, efficiency60% and wavelength 0.8μm.
23. The radiative and non radiative lifetimes of an LED are 80ns and 120ns respectively. Determine total carrier recombination time and the power internally generated with in the device when the peak emission wavelength is 0.87um at a drive current of 50mA
24. A solar cell having 2cm^2 area under illumination of 10 mW per cm^2 gives the maximum power output of 21mW. If its short circuit current and open circuit voltages are 150mA and 400mV respectively. Calculate the fill factor and percentage efficiency of the cell.

25. A solar cell having fill factor of 0.77 gives the maximum output of 20mW. Then calculate its I_{SC} and efficiency with V_{OC}=400mV

Unit: V: Fibre Optics

Numericals:

26. What is the attenuation of power in dB/km of an optical fibre when it losses 85% of its power after travelling 0.5Km?
27. A step-index fibre has a numerical aperture of 0.26, a core refractive index of 1.5 and a core diameter of 100micrometer. Calculate the acceptance angle
28. An optical fibre has NA of 0.20 and cladding refractive index of 1.59. Determine the acceptance angle for fibre in water which has refractive index of 1.33
29. Calculate the refractive index of core and cladding of an optical fibre. The NA and fractional difference between the refractive indices of core and cladding of the optical fibre are 0.22 and 0.012 respectively.
30. In an optical fiber, the core has a refractive index equal to 1.45 and a cladding of refractive index of 1.42
    i. What is the speed of light inside the core?
    ii. What is the critical angle at the core-cladding interface?
31. A step indexed fibre has a core index 1.49, diameter 35micro meters and fractional index difference 0.02. If the operating wavelength is 1.2 micrometers, find the V-number and the number of modes supported by the fibre.
32. A multimode step index fibre having core refractive index of 1.458 and relative refractive difference of 10%.If the number of modes propagating at a wavelength of 1.3micro meter is 1000, find the diameter of the core?
33. An optical fibre made of silica glass has a relative refractive index difference of20% and the acceptance angle of the fibre is 20.6^{o}.Find the refractive index of core.