INDIAN INSTITUTE OF INFORMATION TECHNOLOGY KOTTAYAM
Department of Electronics and Communication Engineering
IEC 111 ELECTRONIC CIRCUITS & MEASUREMENTS
First Mid Semester Examination, Dec 17, 2022

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Time: 10:00 – 11:30 AM | **Semester I** | Max marks: 50

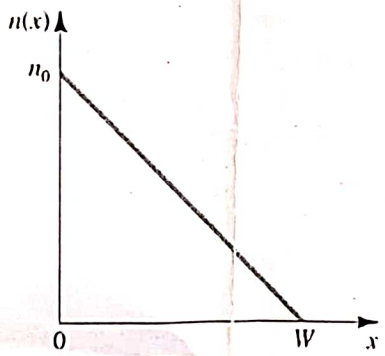
Answer all questions

1. (a) If silicon is doped with boron, _____–type semiconductor is obtained. (1)
   (b) The unit of current density (J_p or J_n) is _____ (1)
   (c) If both N_A and N_D are increased by a factor of 10 each, the junction built-in voltage increases by _____ (1)

   Write the formulae for:

   (d) Approximate hole concentration in a doped (doping concentration=N_D atoms/cm^3) n-type semiconductor, p_n = _____ (1)
   (e) Diffusion electron current density in a semiconductor material, J_n = _____ (1)

2. The linear electron-concentration profile shown in the figure below has been established in a piece of silicon. If $n_o=10^{17}/cm^3$ and W=1μm, find the electron-current density in microamperes per micron squared ($\mu A/\mu m^2$). If a diffusion current of 1 mA is required, what must the cross-sectional area (in a direction perpendicular to the page) be? Recall that D_n=35 cm^2/s. (5)



3. A young designer, aiming to develop intuition concerning conducting paths within an integrated circuit, examines the end-to-end resistance of a connecting bar 15 μm long, 4μm wide and 2μm thick made of various materials. The designer considers: (5)

   (a) intrinsic silicon ~~n-doped silicon with $N_D=5\times10^{18}/cm^3$~~ $B=7.3\times10^{15}$
   (b) n-doped silicon with $N_D=5\times10^{18}/cm^3$
   (c) n-doped silicon with $N_D=5\times10^{16}/cm^3$

(d) p-doped silicon with $N_A = 5 \times 10^{16}/\text{cm}^3$

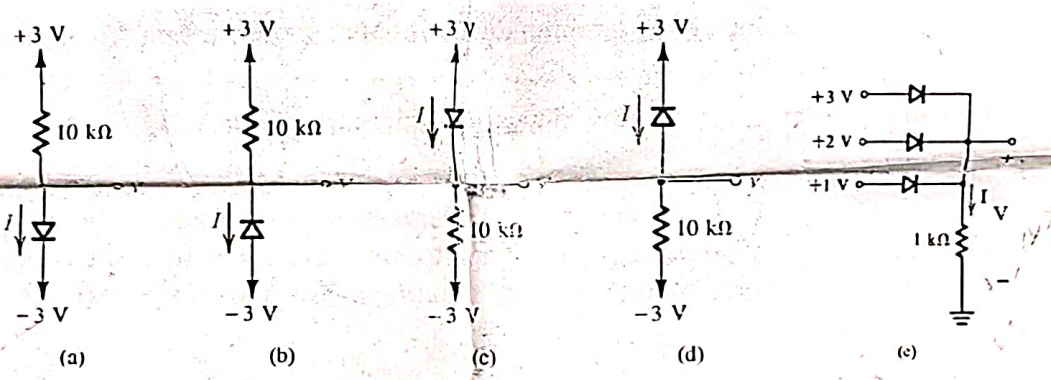
(e) aluminium with resistivity of 4.8 $\mu\Omega$.cm.

Find the resistance in each case. For intrinsic silicon, $\mu_n = 1350\text{cm}^2/\text{V.s}$, $\mu_p = 480\text{cm}^2/\text{V.s}$. Assume room temperature T=27°C. For doped silicon, assume $\mu_n = 3\mu_p = 1200cm^2/\text{V.s}$. (Recall that $R = \rho l/A$)

4. Calculate the built-in voltage of a junction in which the p and n regions are doped equally with 5×10^{16} atoms /cm^3. With the terminals left open, what is the width of the depletion region, and how far does it extend into the p and n regions? If the cross-sectional area of the junction is 20 μm^2, find the magnitude of the charge stored on either side of the junction. The relative permittivity of silicon, ϵ_r is 11.7 and the permittivity of free space is $\epsilon_o = 8.854 \times 10^{-12}$F/m. Charge of electron is 1.6×10^{-19} C. (5)

5. Derive an analytical expression that describes the current-voltage relationship of the pn junction, when a voltage V is applied across the junction. Plot the minority carrier concentration profile in the n and p regions ($p_n(x)$ and $n_p(x)$) when the bias voltage is applied. (10)

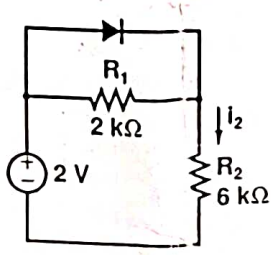
6. For the circuits shown in figure below, find the values of voltages and currents indicated. Assume the diodes are ideal. (5)



7. (a) Draw the circuit diagrams of half-wave rectifier, full-wave rectifier using center-tapped transformer and bridge rectifier. Assuming ideal diodes, sketch the input and output waveforms for sinusoidal inputs. (3)

   (b) Derive the expressions for average (dc) value and root-mean-squared (rms) value of both half and full wave rectifier output voltage. Show that a full-wave rectifier is twice as efficient as a half-wave rectifier. (7)

8. Assume that the diode in the figure has V_{on} =0.7V, but is otherwise ideal. Find the value of the current i_2. (5)



$A = 8.62 \times 10^{-5}$