RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. FOURTH SEMESTER EXAMINATION, MAY 2025

SECOND YEAR [BATCH 2023-27]

Date : 08/05/2025 **PHYSICS**

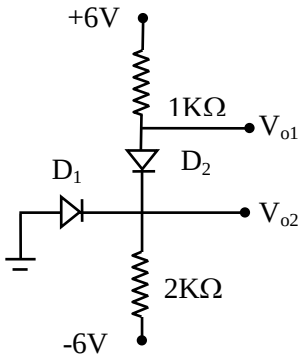
Time : 11 am – 1 pm **Paper : 4PHYMJC3** Full Marks : 50

Answer **any five** from the following questions: [5×10]

1. a) What are the factors determining (i) the width of an energy band in a crystal and (ii) the number of energy levels in the band?
   b) At high temperature an extrinsic semiconductor behaves like an intrinsic one. why?
   c) What is a degenerate semiconductor? Draw the energy band diagram of a n-type and p-type degenerate semiconductor.
   d) Derive Einstein relationship between mobility and diffusion constant. [2+2+(1+1+1)+3]

2. a) For an unbiased p-n junction, sketch the variation of the space charge, electric field, electrostatic potential as a function of distance across the junction.
   b) An abrupt Si p-n junction has $N_d = 10^{18} cm^{-3}$ on one side and $N_d = 5\times10^{15}\ cm^{-3}$ on the other side with $n_i = 1.5\times10^{10} cm^{-3}$
   (i) Calculate the Fermi level position at 300k in the p and n regions.
   (ii) Draw an equilibrium band diagram for the junction and determine the contact potential V_0 from the diagram.
   (iii) What are the difference between Zener Breakdown and Avalanche Breakdown. [3+4+3]

3. a) Consider the diodes are ideal, find the voltage V_{01} & V_{02} in the circuit shown below.



   b) What is the difference between normal diode & LED.
   c) The band gap of GaAsP is 1.98 eV. Determine the wavelength (λ) of the EM radiation that is emitted upon direct recombination of electrons and holes in the sample.
   d) Draw a full-wave rectifier circuit with L-Section filter and find approximate expressions for ripple factor. [3+2+2+3]

4. a) Explain why the base thickness is made narrower than emitter and collector thickness.
   b) Explain with necessary diagram the various current components of an n-p-n transistor.
   c) While designing amplifiers with BJT, what is the desired position of the Q-point for a minimum distortion and why? What is base width modulation?
   d) A transistor amplifier in CE mode is used to transfer signal from a source of internal resistance 1 kΩ to an output load of 20 kΩ. Find the current gain of the amplifier. It is given that: h_{ie} = 1 kΩ, $h_{re} = 2.5 \times 10^{-4}$, h_{fe} = 150 , and $1/h_{oe}$ = 40 kΩ . [1+3+(2+2)+2]

5. a) What is common collector configuration? Explain why it is also known as emitter follower?
   b) Obtain expression for the voltage gain of an RC-coupled amplifier in the high frequency ranges.
   c) The mid-band gain of an RC coupled amplifier is 80. At 100 Hz and 100 kHz frequencies, the gain falls to 40. Determine the half-power frequencies of the amplifier.
   d) Show that negative feedback is useful for enhancement of the stability of an amplifier. [(1+1)+3+3+2]

6. a) Write down the equation for gain with feedback and hence explain the following conditions.
   (i) If $A\beta+1 < 1$,
   (ii) If $A\beta+1 > 1$,
   (iii) If $A\beta+1 = 0$,
   (iv) If $A\beta+1 >> 1$ where symbols have their usual meaning.
   b) Derive the frequency of oscillation and the oscillation condition for a Wein-bridge oscillator.
   d) Mention the modifications needed to convert a mono-stable multivibrator to a bistable multivibrator. [(1+1+1+1)+4+2]

7. a) What is peak detector circuit? If the output load capacitor of a peak detector is replaced by a resistance, then what should be the output signal. Explain in brief.
   b) Draw and explain the working of a 4-bit R-2R type DAC designed using OPAMP.
   c) What do you mean by step-size in ADC or DAC? An ADC, which is capable of providing 4-bit binary output, is designed with the help of a 4-bit DAC. The DAC gives analog output of 3.0 Volt for binary input of (1111). Find the step size and also the binary output of the ADC for input voltage of 1.85 Volt. [(1+2)+4+(1+2)]

8. a) What do you mean by pinch off in a FET and explain its behavior after pinch off with suitable diagram. An n-channel JFET (made of Si, with dielectric constant 12) with a channel half width $a = 3\times10^{-6}\ m$ is doped with a concentration $N_d = 10^{21} m^{-3}$. Find the pinch off voltage. Also, obtain the value of $V_{DS,\,sat}$ for V_{GS} = -2.5V.

   b) Draw a schematic diagram for Depletion type PMOS. Explain how the same MOS can act as a Depletion type and also as an Enhancement type MOS.

   c) Compare transfer characteristics of p-channel and n-channel MOSFETs. [(1+2+3)+(1+2)+1]

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