2021

PHYSICS

[HONOURS]

Paper : V

Full Marks : 100 Time : 4 Hours

The figures in the right-hand margin indicate marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP–A

1. Answer any **ten** questions: 2×10=20

i) Explain the statement : "BJT is a current-controlled device, but JFET is a voltage-controlled device".

ii) Draw the I-V characteristics of a photodiode and indicate how intensity of high is measured.

iii) What is MUF and critical frequency in the context of radiowave propagation?

iv) Define mobility of charge carrier. Mention its S.I unit.

v) Define power gain and explain its decibel unit.

vi) Distinguish between normal and anomalous dispersion.

vii) Establish the relationship between entropy and function of probability.

viii) A Si sample is doped with 10^{17} Arsenic (AS) atom/cm^3. Enumerate the equilibrium hole concentration at 300K. Given intrinsic carrier concentration of Si is $10^{10}/cm^3$ at 300K.

ix) Explain the doublet structure of the spectra of alkali atoms.

x) What do you mean by 'space quantization'?

xi) Define Fermi energy of metal at absolute zero and at any temperature other than zero.

xii) State Wilson-Sommerfeld quantization rule.

xiii) Define Brewster's angle.

xiv) Obtain the maximum range of space-wave propagation from a transmitting antenna of height 120m (take radius of earth 6400km).

xv) Explain the reasons behind the blue colour of the sky.

xvi) Convert $(275.875)_{10}$ into equivalent binary number.

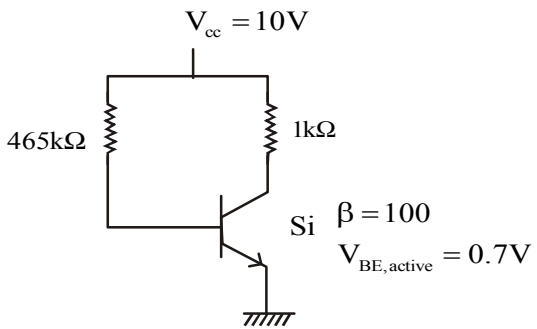
GROUP–B

(Electronics)

Answer any **two** questions: 5×2=10

2. What is a tunnel diode? Draw its I-V characteristic curve and show the negative resistance region. Explain it in brief using energy band diagram. Why do the word tunnel is used? 1+1+2+1

3. What do you mean by the quiescent point of a transistor? Determine the Q-point of the following: 5



4. Draw a circuit giving explanation of the design, using OPAMPS (one or more) which given an output given as

$$v_0 = 4v_1 + 6v_2$$

where v_1 and v_2 are the two input signals to the circuit. 5

5. What is a multiplexer? Desing a 4 : 1 multiplexer using NAND gates only, indicating the excitation table of the same. 1+4=5

Answer any **one** question: 10×1=10

6. Draw the circuit diagram of an OP-AMP based RC phase shift oscillator. Explain the principle of operation of the same. Determine the frequency of oscillation and also the condition of sustained oscillation. 2+2+6=10

7. a) What do you mean by amplitude modulation? Explain the principle of operation of an amplitude modulator.

   b) A 10 kW carrier is amplitude modulated to a depth of 60%. Calculate the total power in the modulated wave and in any one side band. Derive the necessary formula.

(2+3)+(2+3)=10

GROUP–C

(Electrodynamics)

Answer any **two** questions: 5×2=10

8. What do you mean by scattering of light? Define scattering cross-section. Explain the reason of using red light as danger signal. 1+2+2=5

9. An electromagnetic wave is incident normally at the boundary of two dielectric media. Establish that the electric field of the reflected and the transmitted wave have the same state of polarisation. 5

10. What is the discrepency in Amperes' law? How it was resolved by Maxwell? Define the displacement current. Is there any conduction of carrier in displacement current? 1+2+1+1=5

11. Using Maxwell's equations show that

    i) a time dependent magnetic fields can not exist without an electric field.

    ii) a uniform electric field can not exist in the presence of a time dependent magnetic field. $2\frac{1}{2}+2\frac{1}{2}=5$

Answer any **one** question: 10×1=10

12. Define Poynting vector. State its dimension. State and establish Poynting's theorem. Calculate the amount of energy radiated in a straight current carrying conductor using this theorem. 1+1+5+3

13. Prove laws of reflection and refraction of electromagnetic waves using Maxwell's EM theory. Considering electric field on the plane of incidence calculate the coefficient of reflection and hence prove the Brewster's law. 3+6+1=10

GROUP–D

(Statistical Mechanics)

Answer any **two** questions: 5×2=10

14. A system of four particles can occupy the energy levels with energies $0, \in, 2\in$ and $3\in$. If the total energy of the system is $3\in$, find the number of microstates assuming that the particles are (i) distinguishable and (ii) indistinguishable. 3+2=5

15. Write down the basic postulates of MB statistics. Derive the expression of MB distribution. 2+3

16. The single particle partition function of a system of N distinguishable particles is $F = CVT^{\frac{3}{2}}$, 'C' being a constant. Calculate the internal energy and the pressure of the system. 5

17. Consider a system consisting of N-free electrons, obtain the expression for the free-energy of this system at OK. 5

Answer any **one** question: 10×1=10

18. State and prove Stirling formula for factorial of very large number. Write down the distribution law obeyed by the electron gas and apply the same to derive Richardson-Dushman equation. 4+6

19. a) Show that for a 2-dimensional electron gas, the number of electrons per unit area is given by

$$n = \frac{4\pi m K_B T}{h^2} \text{ in } \left(e^{E_F/K_B T} + 1\right)$$

symbols have their usal meaning.

b) Discuss comparatively the basic postulates of MB, BE and FD statistics. 6+4=10

GROUP–E
(Atomic Physics)

Answer any **two** questions: 5×2=10

20. State Bhor's correspondence principle. Explain the principle mentioning its significance. Give an example of this principle. 5

21. Describe the essential features of the Stern-Gerlach experiment. Explain how the outcome of the experiment could be understood in terms of electron spin. 3+2=5

22. Calculate the (a) wave number, (b) wavelength and (c) frequency of the H_α line of Hydrogen, assuming that the nucleus has infinite mass. Find the wavelength of the Balmer series limit. Given Rydberg constant, $R = 1.097 \times 10^7 m^{-1}$. 3+2=5

23. State and explain Pauli exclussion principle. Prove that a shell can accomodate $2n^2$ electrons, n being the principal quantum number. 5

Answer any **one** question: 10×1=10

24. What are normal and anomalous Zeeman effects. Give the theory of Zeeman effect when the atom is placed in a weak magnetic field and explain the results in the context of sodium D-lines. What happens if the external magnetic field is gradually increased to a very high value? 2+5+3=10

25. a) What is Compton effect?

b) What are the differences between Compton effect and Raman effect?

c) Establish the Einstein's photoelectric equation.

d) Estimate the velocity of the photoelectron emitted by a radiation of wavelength 3000 Å from a metal having work function of 2.28eV. 1+2+4+3=10