

**2020**  
**PHYSICS**  
**(Theory)**

**Full Marks : 70**

**Pass Marks : 21**

**Time : Three hours**

*Attempt all Questions.*

*The figures in the right margin indicate full marks for the questions.*

*Question Nos. 1 to 10, are "Very Short Answer" type questions carrying 1 mark each.*

1. Define dipole moment vector of an electric dipole. Give the direction of the vector. 1
2. A resistor is connected across a cell of emf 1.5 V having an internal resistance of  $1\ \Omega$ . If a current of 200 mA flows through the resistor, find the potential difference between the electrodes of the cell. 1
3. A current of  $\frac{1}{\pi}$  ampere flows in a circular loop of radius 10 cm. Find the magnetic dipole moment of the loop. 1
4. Define magnetic flux and give its SI unit. 1
5. Give the frequency range of FM (frequency modulated) radio band. 1
6. Assume that light of wavelength  $0.5\ \mu\text{m}$  is coming from a star. What is the limit of angular resolution in radians of a telescope whose objective has a radius 122 cm.? 1

P.T.O.

7. What is the de-Broglie wavelength of an electron with kinetic energy of 100 eV? 1
8. Define atomic mass unit ( $u$ ). 1
9. Find the shortest wavelength in the Balmer series of hydrogen atomic spectrum. (Rydberg constant,  $R = 1.097 \times 10^7 m^{-1}$ ). 1
10. Define small signal current gain of a transistor in common emitter configuration. 1

*Question Nos. 11 to 20 are 'Short Answer Type-II' questions carrying 2 marks each.*

11. Find the area in sq km of the plates of a parallel plate capacitor of capacitance 2F, given that the separation between the plates is 0.5 cm. ( $\epsilon_0 = 8.85 \times 10^{-12} C^2 N^{-1} m^{-2}$ ) 2
12. The number density of free electrons in a copper conductor is  $8.5 \times 10^{28} m^{-3}$ . How long does an electron take to drift from one end of a wire 3.0 m long to its other end? The area of cross section of the wire is  $2.0 \times 10^{-6} m^2$  and it is carrying a current of 3.0 A. ( $e = 1.6 \times 10^{-19} C$ ) 2
13. Distinguish between paramagnetic and diamagnetic materials in terms of (i) susceptibility and (ii) their behavior in an external non-uniform magnetic field. 2
14. In a chamber, a uniform magnetic field of  $6.5 \times 10^{-4} T$  is maintained. An electron is shot into the field with a speed of  $4.8 \times 10^6 ms^{-1}$  normal to the field. Determine the radius of the circular orbit of the electron. ( $e = 1.6 \times 10^{-19} C$ ,  $m_e = 9.1 \times 10^{-31} kg$ ) 2
15. Give any two reasons for small energy losses in transformer and write how these can be minimised. 2

16. The magnetic field in a plane electromagnetic wave is given by

$$B_y = (2 \times 10^{-7}) T \sin(0.5 \times 10^3 z - 1.5 \times 10^{11} t)$$

Write the expression for the electric field. ( $c = 3 \times 10^8 \text{ ms}^{-1}$ ) 2

17. Explain why thin clouds look white while clear sky looks blue. 2

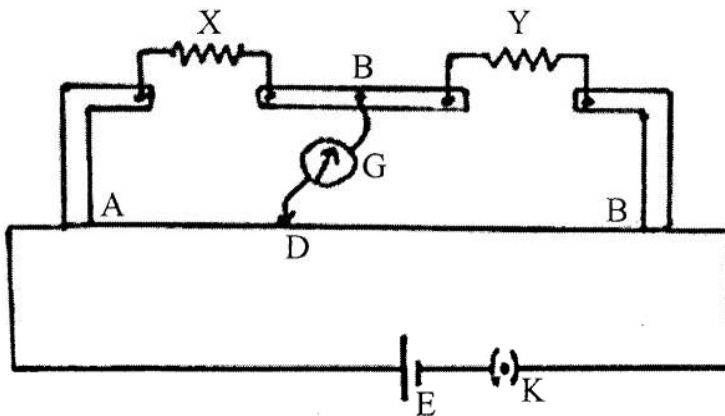
18. Define threshold frequency in photoelectric effect and describe the failure of wave theory to explain the existence of a threshold frequency for a photosensitive material. 2

19. Explain how a depletion region is formed in a junction diode. 2

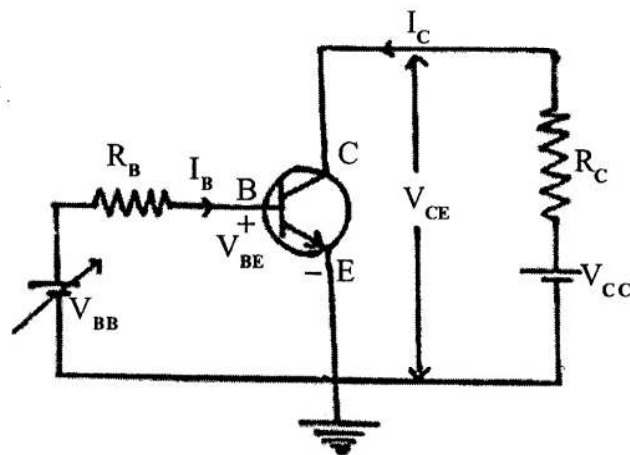
20. A message signal of frequency 5 kHz and peak voltage of 10 V is used to modulate a carrier wave of frequency 1 MHz and peak voltage of 20 V. Determine modulation index, the side bands produced. 2

*Question Nos. 21 to 27 are 'Short Answer Type-I' questions carrying 3 marks each.*

21. In the meter bridge shown in the figure, the balance point is found to be at 40 cm from the end A, when the resistor Y is of  $15 \Omega$ . Determine the
- (i) resistance of X
  - (ii) the balance point of the bridge if X and Y are interchanged. 3



22. A circular loop of radius  $5\text{ cm}$  carrying a current of  $\frac{10}{\pi}\text{ A}$  is held in a vertical plane containing north to south direction. The sense of current is clockwise for an observer looking at the coil facing east. Give the magnitude and direction of the magnetic field due to the coil at the centre. ( $\mu_0 = 4\pi \times 10^{-7}\text{ TmA}^{-1}$ ) 3
23. A small bulb is placed at the bottom of a tank containing water to a depth of  $98\text{ cm}$ . What is the area of the surface of water through which light from the bulb can emerge out. Refractive index of water is  $\frac{4}{3}$ . (Consider the bulb to be a point source). 3
24. Draw a neat ray diagram showing the formation of final image by a compound microscope. 3
25. A heavy nucleus X of mass number 240 and binding energy per nucleon  $7.6\text{ MeV}$  is split into two nuclei each of mass numbers 120 of binding energies per nucleon  $8.5\text{ MeV}$ . Estimate the energy Q released per fission of the nucleus X into two nuclei each of mass numbers 120. 3
26. In the figure, the  $V_{BB}$  supply can be varied from  $0\text{ V}$  to  $5.0\text{ V}$ . The transistor has  $\beta_{dc} = 250$  and  $R_B = 100\ \Omega$ ,  $R_C = 1\text{ k}\Omega$ ,  $V_{CC} = 5.0\text{ V}$ . Assume that when the transistor is saturated,  $V_{CE} = 0\text{ V}$ , and  $V_{BE} = 0.8\text{ V}$ . Calculate the minimum base current and input voltage for which the transistor will reach saturation. 3



27. A transmitting antenna at the top of a tower has a height 32 m and the height of the receiving antenna is 50 m. What is the maximum distance between two such antennas for satisfactory communication in line-of-sight (LOS) mode ? Given the radius of earth is  $6.4 \times 10^6 m$ . 3

*Question Nos. 28 to 30 are 'Long Answer Type' questions carrying 5 marks each.*

28. Using Gauss's law of electrostatics obtain the expression for the electric field at a point near an infinitely long thin straight wire with uniform linear charge density  $\lambda$ . 5

OR

Obtain the expression for the electric potential due to an electric dipole (consisting of two charges  $q$  and  $-q$  separated by a small distance  $2a$ ) at a point far away from the dipole. 5

29. A rectangular wire of sides 10 cm and 5 cm with a small cut is moving out of a region of uniform magnetic field of magnitude 0.5 T directed normal to the loop. What is the emf developed across the cut if the velocity of the loop is  $1 cm s^{-1}$  in a direction normal to the (a) longer side, (b) shorter side of the loop ? For how long does the induced voltage last in each case 2+2+1=5

OR

A sinusoidal voltage of peak value  $230\sqrt{2} V$  with variable frequency is applied

to a series LCR circuit in which  $R = 5\Omega$ ,  $L = \frac{250}{\pi} mH$ , and  $C = \frac{400}{\pi} \mu F$ .

- (a) Find the frequency of the source at which resonance occurs.  
(b) Calculate the impedance, the r.m.s. current and the power dissipated at resonance condition. 2+3=5
30. The radii of curvature of the faces of a double convex lens made of glass, are 10 cm and 15 cm. Its focal length is 12 cm. (a) Find the refractive index of glass. (b) Calculate its new focal length if the lens is completely immersed in water (Refractive index of water is  $\frac{4}{3}$ ). 2+3=5

OR

In a Young's double slit experiment, two coherent sources each of wavelength  $500\text{ nm}$  are placed  $0.5\text{ mm}$  apart and the screen is placed  $1\text{ m}$  away.

- (a) Find the fringe width of the interference pattern observed on the screen  
(b) Find the distance of the second dark fringe and the fourth bright fringe from the central fringe. 2+3=5

*Question Nos. 31 to 34 are 'Multiple Choice Type' questions carrying 1 mark each. Choose the correct answer out of the four alternatives and rewrite the correct answer.*

31. Two cells of emf  $6\text{ V}$  and  $3\text{ V}$  of internal resistances  $1\ \Omega$  and  $2\ \Omega$  respectively are connected in parallel with their positive terminals together and similarly the negative terminals together. The equivalent emf of the combination would be 1
- A.  $8\text{ V}$   
B.  $4\text{ V}$   
C.  $5\text{ V}$   
D.  $10\text{ V}$
32. A laser produces monochromatic light of wavelength  $530.4\text{ nm}$ . The power emitted is  $3.0\text{ mW}$ . The number of photons emitted per second on an average is  $(h = 6.63 \times 10^{-34}\text{ Js}, c = 3 \times 10^8\text{ ms}^{-1})$  1
- A.  $8.0 \times 10^{15}$   
B.  $5.0 \times 10^{15}$   
C.  $8.0 \times 10^{16}$   
D.  $5.0 \times 10^{16}$ .