

**2 0 1 9**

**PHYSICS**

**( Theory )**

*Full Marks : 70*

*Time : 3 hours*

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

*General Instructions :*

- (i) All questions are compulsory.
- (ii) All the answers are to be written in the Answer Script.
- (iii) There is no overall choice. However, internal choices have been provided in two questions of *two* marks, two questions of *three* marks and one question of *five* marks.
- (iv) Use of non-programmable ordinary scientific calculator and/or logarithmic table is allowed.
- (v) Use of Mobile Phones, Pagers and such other electronic gadgets is not allowed in the Examination Hall.

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(vi) Use the following values of physical constants wherever necessary :

Speed of light in vacuum,  $c = 3 \times 10^8 \text{ m s}^{-1}$

Planck's constant,  $h = 6.63 \times 10^{-34} \text{ J-s}$

Permittivity of free space,

$$\epsilon_0 = 8.86 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$$

Permeability of free space,  $\mu_0 = 4\pi \times 10^{-7} \text{ T m A}^{-1}$

Mass of electron,  $m_e = 9.11 \times 10^{-31} \text{ kg}$

Mass of proton,  $m_p = 1.67 \times 10^{-27} \text{ kg}$

Electronic charge,  $e = 1.6 \times 10^{-19} \text{ C}$

GROUP—A

( Multiple choice type questions )

Choose and write the correct option for the following :

$$\frac{1}{2} \times 8 = 4$$

1. The force between two equal point charges separated by a certain distance is  $F$ . If the distance between them is doubled and their individual charges are also doubled, then the force between them is

(a)  $F$

(b)  $2F$

(c)  $F/2$

(d)  $F/4$

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2. An electric dipole of dipole moment  $\vec{p}$  is placed in a uniform electric field of strength  $\vec{E}$ . If  $\theta$  is the angle between the positive direction of  $\vec{p}$  and  $\vec{E}$ , then potential energy of the dipole is largest when  $\theta$  is

(a)  $0^\circ$

(b)  $90^\circ$

(c)  $180^\circ$

(d)  $45^\circ$

3. A charged particle of mass  $m$  and charge  $q$  moves along a circular path with a velocity  $v$  perpendicular to a magnetic field  $\vec{B}$ . The radius of the circular path is

(a)  $\frac{mv}{qB}$

(b)  $\frac{mB}{qv}$

(c)  $\frac{mq}{vB}$

(d)  $\frac{qv}{mB}$

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4. To convert a galvanometer into a voltmeter, we must connect a
- (a) high resistance in parallel with the galvanometer
  - (b) high resistance in series with the galvanometer
  - (c) low resistance in parallel with the galvanometer
  - (d) low resistance in series with the galvanometer
5. A step-up transformer operates on a 230 V line and supplies current of 2 A to a load. The ratio of the primary and secondary windings is 1 : 25. The current in the primary coil is
- (a) 12.5 A
  - (b) 15 A
  - (c) 25 A
  - (d) 50 A
6. When current changes from 2A to 2A in 0.05 s, an e.m.f. of 8 V is induced in a coil. The coefficient of self-induction of the coil is
- (a) 0.8 H
  - (b) 0.4 H
  - (c) 0.1 H
  - (d) 0.2 H

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7. The displacements of interfering light waves are  $y_1 = 4 \sin t$  and  $y_2 = 3 \sin(t + \pi/2)$ . The amplitude of the resultant wave is
- (a) 5
  - (b) 7
  - (c) 1
  - (d) 0
8. The slits in Young's experiment have widths in the ratio 1:16. The ratio of maxima and minima in the interference pattern is
- (a) 1:16
  - (b) 1:4
  - (c) 5:3
  - (d) 25:9

GROUP—B

( Very short answer type questions )

Answer the following questions in *one* sentence/step each : 1×8=8

9. Using an expression for drift velocity, show that the mobility of free electron is directly proportional to its relaxation time. 1
10. A wire of resistance 1000  $\Omega$  and length  $l$  is increased to twice its original length. Calculate its new resistance. 1

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- 11.** Name the electromagnetic radiation which is used—  
(a) to kill cancerous cells in human;  
(b) to produce dehydrated fruits. ½+½=1
- 12.** What is carrier wave? 1
- 13.** What is diffraction of light? 1
- 14.** What is the effect of intensity of incident light on photoelectric current? 1
- 15.** Mention one practical application of logic gates. 1
- 16.** Why VHF, UHF and microwaves cannot be transmitted by sky wave propagation? 1

GROUP—C

( Short answer type-I questions )

Answer the following questions within 30 words each wherever applicable : 2×8=16

- 17.** *Either*  
Use Gauss's theorem to derive an expression for electric field due to a uniformly charged spherical shell at a point outside the shell. 2
- Or*
- Derive an expression for energy stored in a charged capacitor. 2

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18. Write down the condition of resonance in series  $L$ - $C$ - $R$  circuit and hence find an expression for the resonant frequency.  $\frac{1}{2}+1\frac{1}{2}=2$

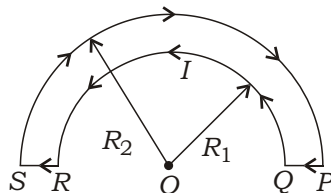
19. An alternating source of e.m.f.  $E = E_0 \sin t$  is applied to a circuit containing a capacitor only. Show that the current leads the e.m.f. by  $\frac{\pi}{2}$  radian. 2

20. Using supplied value of  $\mu_0$  and  $\epsilon_0$ , find the speed of electromagnetic waves in vacuum. 2

21. *Either*  
Two parallel wires carrying current in the same direction attract each other while two beams of electrons travelling in the same direction repel each other. Explain why. 2

*Or*

The wire loop  $PQRSP$  formed by joining two semi-circular wires of radii  $R_1$  and  $R_2$  carries a current  $I$  as shown in the figure below. Find the magnitude of magnetic field at  $O$ . 2



22. (a) What are isotones? 1

(b)  $A$        $A_1$        $A_2$        $A_3$

The mass number and atomic number of  $A$  are 180 and 72 respectively. What are these numbers for  $A_3$ ? 1

23. A semiconductor has equal electron and hole concentration  $6 \times 10^8 \text{ m}^{-3}$ . On doping with a certain impurity, electron concentration increases to  $9 \times 10^{12} \text{ m}^{-3}$ . Calculate the new hole concentration. Also identify the new semiconductor.  $1\frac{1}{2} + \frac{1}{2} = 2$

24. What is the basic principle of a rectifier? Draw a neat circuit diagram of a full-wave rectifier circuit.  $1 + 1 = 2$

GROUP—D

( Short answer type-II questions )

Answer the following questions within 30 to 40 words each wherever applicable :  $3 \times 9 = 27$

25. What is drift velocity of electrons? Show that electric current flowing through a conductor is directly proportional to the drift velocity.  $1 + 2 = 3$

26. *Either*  
Derive an expression for coefficient of mutual induction for two long solenoids. 3

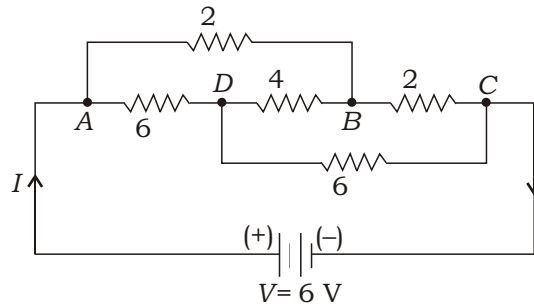
*Or*

With the help of a phasor diagram, find an expression for impedance ( $Z$ ) in a series  $L$ - $C$ - $R$  circuit. 3



27. (a) Why do we prefer potentiometer to compare the e.m.f.s of cells than a voltmeter? 1

(b) Find  $I$  in the following circuit :



[Assume negligible internal resistance of the cell.] 2

28. (a) Derive de Broglie wave equation for material particles. 2

(b) Why does photoelectric emission not take place if the frequency of incident radiation is less than threshold frequency? 1

29. State radioactive decay law. Derive the relation  $N = N_0 e^{-\lambda t}$ , where symbols have their usual meanings. 1+2=3

30. *Either*  
Using Huygens' principle, establish the laws of reflection. 3

*Or*  
Find an expression for combined focal length of two thin coaxial convex lenses placed in contact. 3

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- 31.** (a) State the postulates of Bohr's theory of hydrogen atom. 2
- (b) Name the series of hydrogen spectrum lying in ultraviolet and visible region.  $\frac{1}{2} + \frac{1}{2} = 1$
- 32.** With the help of labelled circuit diagram, explain the working of a transistor as an amplifier using *n-p-n* transistor in CE configuration.  $1 + 2 = 3$
- 33.** (a) Obtain an expression for the coverage range in space wave propagation in terms of height of the antenna. 2
- (b) What is modulation factor? 1

GROUP—E

( Long answer type questions )

Answer the following questions in 70 to 80 words each wherever applicable :  $5 \times 3 = 15$

- 34.** Derive an expression for the electric potential at any point at a distance  $r$  from the centre of an electric dipole. Hence find the potential if the point lies on (i) axial line and (ii) equatorial line.  $4 + \frac{1}{2} + \frac{1}{2} = 5$

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**35.** Describe the principle and working of a moving-coil galvanometer and hence show that the deflection of the coil is directly proportional to the current flowing through it. What is the effect of the radial magnetic field in a moving-coil galvanometer? 1+3+1=5

**36.** *Either*  
Derive lens maker formula for a thin convex lens. 5

*Or*

With the help of a neat diagram, explain the working of a compound microscope. Obtain an expression for its magnifying power when the final image is formed at least distance of distinct vision. 2+3=5

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