

2 0 1 4

PHYSICS

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) Write the answers of a particular Group in one place.
- (iv) Marks allotted for each question are indicated against it.
- (v) There is no overall choice. However, internal choices have been provided in two questions in Group—C, two questions in Group—D and one question in Group—E.
- (vi) Use of non-programmable scientific calculator and/or logarithmic tables is allowed.
- (vii) Use of Mobile Phones, Pagers and such other electronic gadgets is not allowed in the Examination Hall.

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(viii) The following values of physical constants are to be used 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, $\epsilon_0 = 8.854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$

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 answer for the following :

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

1. A glass rod rubbed with a silk cloth acquires a charge of $+19.2 \times 10^{-18} \text{ C}$, then

- (a) number of protons gained by the glass rod is 120
- (b) number of electrons lost by the glass rod is 12
- (c) number of electrons lost by the glass rod is 120
- (d) number of electrons gained by the silk cloth is 120

HS/XII/Sc/Ph/14/45

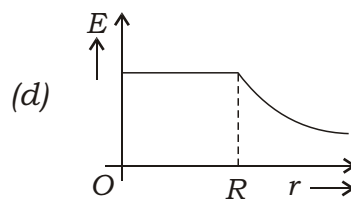
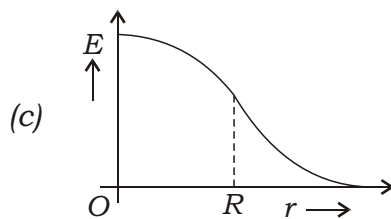
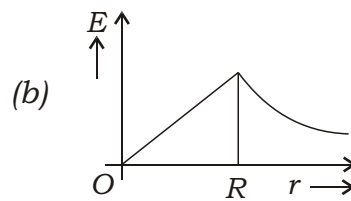
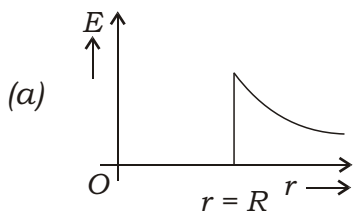
(3)

2. The horizontal component of earth's magnetic field at a place is $\sqrt{3}$ times the vertical component. The value of the dip at this place is
- (a) 60°
 - (b) 90°
 - (c) 0°
 - (d) 30°
3. An electron has the same linear momentum as that of a proton. Which of the following is correct?
- (a) Kinetic energy of a proton = Kinetic energy of an electron
 - (b) Kinetic energy of a proton > Kinetic energy of an electron
 - (c) Kinetic energy of a proton < Kinetic energy of an electron
 - (d) Kinetic energy is independent of linear momentum
4. In an a.c. circuit, an alternating voltage $e = 200\sqrt{2} \sin 100t$ volts is connected to a capacitor of capacitance 1 F. The r.m.s. value of current in the circuit is
- (a) 200 mA
 - (b) 20 mA
 - (c) 10 mA
 - (d) 100 mA

5. Monochromatic light of wavelength 4500 \AA is incident on a clean metal surface of work function 2.3 eV . The maximum kinetic energy of ejected photoelectrons is 0.5 eV , then energy of the incident photon is
- (a) 1.8 eV
 - (b) 2.8 eV
 - (c) 11.5 eV
 - (d) 12.8 eV
6. A long magnetic needle of length $2L$, magnetic moment M and pole strength m units is broken into two at the midpoint. The magnetic moment and pole strength of each piece will be
- (a) $\frac{M}{2}, \frac{m}{2}$
 - (b) $M, \frac{m}{2}$
 - (c) $\frac{M}{2}, m$
 - (d) M, m
7. In an a.c. generator
- (a) mechanical energy is converted to electrical energy
 - (b) electrical energy is converted into mechanical energy
 - (c) electrical energy is converted into heat energy
 - (d) None of the above

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8. Which graph best represents the variation of electric field intensity as a function of distance from the centre of a uniformly charged spherical shell of radius R ?



GROUP—B

(Very short answer type questions)

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

9. The specific resistances of copper, silver and constantan are 1.78×10^{-6} -cm, 1×10^{-6} -cm and 48×10^{-6} -cm respectively. Which is the best conductor and why?

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- 10.** Power of 60 W is being supplied to an electrical appliance under a potential difference of 240 volts. What is the current flowing through the appliance?

- 11.** Find the magnifying power of an astronomical telescope for normal adjustment if the focal lengths of its objective and eyepiece are 50 cm and 10 cm respectively.

- 12.** Why is modulation essential for long distance transmission of signal?

- 13.** What is dark current?

- 14.** Mention two essential functions of a detector circuit during the process of demodulation.

- 15.** What is total internal reflection?

- 16.** Draw a block diagram of a detector for an amplitude-modulated signal.

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GROUP—C

(Short answer type-I questions)

Answer the following questions within 30 words each :

2×8=16

- 17.** State Biot-Savart law and express the law in vector form. 2

- 18.** *Either*

A parallel plate capacitor is made of two foils, each of surface area 2 m^2 , separated by paper $7 \times 10^{-5} \text{ m}$ thick. What is its capacitance? [$K = 3.5$ for paper] 2

Or

An electric dipole consists of two opposite charges of magnitude 1 C each, separated by a distance of 3 cm . The dipole is placed in a uniform electric field of $4 \times 10^5 \text{ N/C}$. Find the maximum torque on the dipole.

- 19.** State Lenz's law and show that it is a consequence of the principle of conservation of energy. 2

- 20.** When a direct current of 5 A is passed through a coil of 1000 turns, the magnetic flux produced is $1.4 \times 10^{-4} \text{ Wb}$. What is the inductance of the coil? 2

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21. *Either*

Show that the volume of a nucleus is directly proportional to its mass number. 2

Or

A radioactive isotope decays in the following sequence :

A A_1 A_2

If the mass number and atomic number of A_2 are 176 and 71 respectively, find the mass number and atomic number of A_1 and A . Which of the three elements are isobars?

22. Draw the logic gate symbols and the truth tables for an AND gate and a NOR gate with two inputs. 1+1=2

23. What is modulation factor? Calculate the modulation factor when signal amplitude is half of the carrier amplitude. 1+1=2

24. Draw a labelled circuit diagram of a common-emitter transistor amplifier. 2

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GROUP—D

(Short answer type-II questions)

Answer the following questions within 30 to 40 words each : 3×9=27

25. With the help of a neat diagram, deduce the condition for balance in a Wheatstone's bridge by applying Kirchhoff's laws. 3

26. (a) Using the expressions for drift velocity (V_d) and current (I), show that $R = \frac{ml}{nAe^2}$, where the symbols have their usual meanings.

(b) The resistance and tolerance of a carbon resistor is given as $R = 48\text{ k } \pm 5\%$. Write down the sequence of colours on the resistor. 2+1=3

27. *Either*

Write down the condition of resonance in a series $L-C-R$ circuit and hence find an expression for the resonant frequency. Also draw the resonance curve in $L-C-R$ circuit. 2+1=3

Or

What is the principle on which a transformer is based? With a simple diagram, briefly describe the working of a transformer. 1+2=3

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- 28.** Write any four properties of electromagnetic waves.
Give two uses of microwaves. 2+1=3

- 29.** *Either*
Find an expression for the combined focal length of two thin coaxial convex lenses placed in contact. 3

Or

- Draw a labelled diagram to show the image formation at the near point due to a compound microscope and hence calculate its magnifying power. 1+2=3

- 30.** Deduce the expression for de Broglie wavelength of an electron accelerated through a potential difference of V volts. Hence find the de Broglie wavelength in \AA associated with an electron accelerated under a potential difference of 100 volts. 3

- 31.** Define half-life of a radioactive substance. Show that half-life of a radioactive substance is inversely proportional to the decay constant. 3

- 32.** Write down the postulates of Bohr's theory of hydrogen atom. 3
- 33.** (a) What is intrinsic semiconductor? Name the type of extrinsic semiconductor obtained when germanium is doped with (i) arsenic and (ii) gallium.
- (b) Draw a neat diagram for a full-wave rectifier circuit. 1+1+1=3

GROUP—E

(Long answer type questions)

Answer the following questions in 70 to 80 words each :

5×3=15

- 34.** Two point charges q and q separated by a short distance $2a$ are placed in free space at points A and B respectively. Derive an expression for the electric potential at a point P whose distance from the centre O of the line AB is r and OP makes an angle with the electric dipole moment \vec{p} . Hence, find the potential if P lies on (i) axial line and (ii) equatorial line. 4+1=5
- 35.** State the Ampere's circuital law. Use the law to find the magnitude of the magnetic field inside a long, straight, air-cored solenoid. Also write the expressions for the magnitude of magnetic field (i) at points near the ends of the solenoid and (ii) inside the solenoid when it is iron-cored. 1+3+1=5

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36.

Either

State and prove Brewster's law and hence show that if ray of light is incident on the refracting surface at a polarising angle, then the reflected and refracted rays are perpendicular to each other.

5

Or

What are coherent sources? In Young's double-slit experiment, show that the fringe width for interference fringes is given by

$$\frac{D}{d}$$

where D is the distance of the screen from the slits, d is the distance between two slits and λ is the wavelength of light used.

1+4=5
