

Total No. of Printed Pages—11

HS/XII/Sc/Ph/OC/20

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PHYSICS

(Theory)

(Old Course)

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 2 marks, two questions of 3 marks and all questions of 5 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.

(2)

(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. An electric dipole consisting of charge $-q$ and $+q$ is placed in a uniform electric field \vec{E} such that its dipole moment \vec{p} makes an angle θ with the direction of \vec{E} . The net force \vec{F} and torque τ acting on the dipole are

(A) $\vec{F} = 0, \tau = 0$

(B) $\vec{F} \neq 0, \tau \neq 0$

(C) $\vec{F} = 0, \tau \neq 0$

(D) $\vec{F} \neq 0, \tau = 0$

(3)

2. When air between the plates of a capacitor is replaced by mica of dielectric constant $k = 6$, then the capacitance of the parallel-plate capacitor
- (A) remains unaffected
 - (B) reduces to $1/6$ times
 - (C) becomes 6 times
 - (D) None of the above
3. The total resistance of two resistors when connected in series is 9Ω and when connected in parallel is 2Ω . The values of two resistances are
- (A) 4Ω and 5Ω
 - (B) 2Ω and 7Ω
 - (C) 3Ω and 6Ω
 - (D) 1Ω and 8Ω
4. Kirchhoff's second law in electricity is based on the law of conservation of
- (A) sum of mass and energy
 - (B) momentum
 - (C) energy
 - (D) charge

(4)

5. To convert a given galvanometer into an ammeter of desired range
- (A) low resistance is connected in series
 - (B) low resistance is connected in parallel
 - (C) high resistance is connected in series
 - (D) high resistance is connected in parallel
6. A charge q moves with velocity \vec{v} in a region where electric field \vec{E} and magnetic field \vec{B} both exist. Then the force acting on the charge q is
- (A) $q\vec{E} + q(\vec{v} \times \vec{B})$
 - (B) $q(\vec{v} \times \vec{B})$
 - (C) $q\vec{E} + q(\vec{B} \times \vec{v})$
 - (D) $q\vec{B} + q(\vec{E} \times \vec{v})$
7. If a convex lens of focal length 80 cm and a concave lens of focal length 50 cm are combined by placing them together in contact, then their resulting power will be
- (A) + 6.5 D
 - (B) - 6.5 D
 - (C) + 7.5 D
 - (D) - 7.5 D

(5)

8. For relaxed eye, the magnifying power of a microscope is

(A) $\frac{v_0}{u_0} \times \frac{D}{f_e}$

(B) $\frac{v_0}{u_0} \times \frac{f_e}{D}$

(C) $\frac{u_0}{v_0} \times \frac{D}{f_e}$

(D) $\frac{u_0}{v_0} \times \left(-\frac{D}{f_e} \right)$

GROUP—B

(Very short answer type questions)

Answer the following questions in *one* sentence/step each :

1×8=8

9. Two equal negative point charges $-2 \mu\text{C}$ each are held 1 m apart. Calculate their potential energy. 1
10. On which factors does the capacitance of a capacitor depend? 1
11. Define resistivity of the material of a wire. State its SI unit. 1
12. A heating element is marked 210 V, 630 W. What is the value of current drawn by the element when connected to a 210 V d.c. source? 1

(6)

- 13.** When a direct current of 2.5 A is passed through a coil of 500 turns, the magnetic flux produced is 1.4×10^{-4} Wb. What is the inductance of the coil? 1
- 14.** Which of the following belong to the electromagnetic spectrum?
 α -rays, β -rays, γ -rays, Cathode rays, X-rays, UV rays, Microwaves, Ultrasonic waves, Radio waves, Infrared rays
Arrange them in order of increasing frequency. 1
- 15.** In Young's double-slit experiment, the separation of the slits is doubled and the distance between the slits and the screen is halved. What will be the effect on the fringe width? 1
- 16.** The stopping potential in an experiment on a photoelectric effect is 1.5 V. What is the maximum kinetic energy of the photoelectron emitted? 1

GROUP—C

(Short answer type-I questions)

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

- 17.** Prove that the energy stored in a parallel-plate capacitor is given by $U = \frac{1}{2} CV^2$, where the symbols have their usual meanings. 2

(7)

18. Write down a simple relation to show the variation of resistance with temperature, and hence define the temperature coefficient of resistance. 2

19. *Either*

In a hydrogen atom, an electron of charge $-e$ revolves in a circular path of radius r with a speed v . Deduce an expression for the magnetic dipole moment of the revolving electron. 2

Or

A moving-coil galvanometer consists of a rectangular coil of n turns, each of area A , suspended in a radial magnetic field of flux density B . At equilibrium position, show that the current passing through the coil is directly proportional to the angle of deflection of the coil. 2

20. *Either*

How is Eddy current produced? Give two applications of Eddy current. 1+1

Or

Define the term 'mutual inductance' and give its SI unit. State two factors on which the coefficient of mutual inductance between a pair of coils depends. 1+1

21. What do you mean by power factor of an a.c. circuit? On what factors does it depend? 1+1

22. What are microwaves? State any two uses of microwaves. 1+1

(8)

23. The binding energies of ${}_8\text{O}^{16}$ and ${}_{17}\text{Cl}^{35}$ are 127.35 MeV and 289.3 MeV respectively. (a) Calculate the binding energy per nucleon of ${}_8\text{O}^{16}$ and ${}_{17}\text{Cl}^{35}$, and (b) state which of the two nuclei is more stable. 1+1
24. What are the basic elements of a communication system? Draw the block diagram of a basic communication system. 1+1

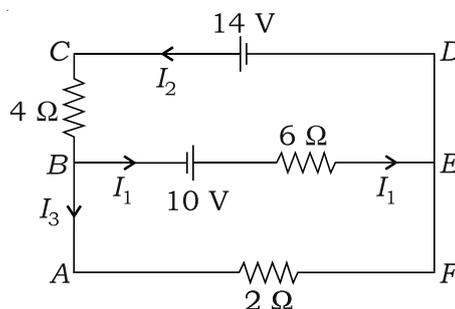
GROUP—D

(Short answer type-II questions)

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

25. Obtain an expression for the electric potential energy of an electric dipole placed in a uniform electric field. State when it will be (a) minimum and (b) maximum. $2 + \frac{1}{2} + \frac{1}{2}$
26. *Either*

In the network shown below



find the currents I_1 , I_2 and I_3 .

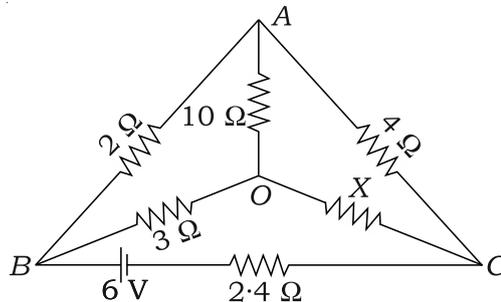
3

(9)

Or

Find the value of the unknown resistance X in the circuit shown in the figure below if no current flows through the section AO . Also calculate the current drawn by the circuit from the battery of e.m.f. 6 V and negligible resistance.

3



27. State the principle of working of a transformer. Explain how it works and mention two of its applications. 1+2

28. *Either*

State Brewster's law. Show that the reflected ray and refracted ray are perpendicular to each other when the angle of incidence is equal to polarizing angle. 1+2

Or

State Huygens' wave principles. Using the principles, verify the law of reflection of light. 1+2

29. (a) What is the frequency of a photon whose energy is 75 eV? 2

(b) Derive Einstein's photoelectric relation. 1

30. Using Bohr's postulates, obtain an expression for the total energy of an electron in the stationary orbit. 3

(10)

- 31.** What is rectification? With the help of a labelled circuit diagram, explain full-wave rectification using semiconductor diode. 1+2
- 32.** Define the terms 'mass defect' and 'binding energy'. How are they related? 1+1+1
- 33.** Calculate the modulation factor when signal amplitude is—
- (a) zero;
 - (b) equal to carrier amplitude;
 - (c) half the carrier amplitude. 1+1+1

GROUP—E

(Long answer type questions)

Answer the following questions in 70 to 80 words each, wherever applicable : 5×3=15

- 34.** *Either*
- (a) Show that the path of a charged particle moving inside the electric field \vec{E} is parabolic in nature. 3
 - (b) A cathode-ray tube is operated at 2500 V. What is the speed of electrons emitted? 2

Or

- (a) Draw a labelled diagram of a cyclotron. Explain its working principle. Show that the frequency is independent of speed and radius of the orbit. 1+1+1

(11)

(b) A cyclotron is to accelerate protons to a kinetic energy of 5.0 MeV. If the strength of the magnetic field in the cyclotron is 2.0 T, find—

(i) the frequency needed for the applied alternating voltage;

(ii) the radius of the cyclotron. 1+1

35.

Either

Establish a relation for refraction at convex spherical refracting surface of a denser medium when—

(a) the image formed is real;

(b) the image formed is virtual. 2½+2½

Or

What is meant by diffraction of light? Deduce the condition for the position of secondary minima of diffraction pattern in term of path difference.

Also show graphically the relative intensity distribution for a single-slit diffraction pattern as a function of $\sin\theta$.

1+3+1

36.

Either

Draw a circuit diagram to study the input and output characteristics of an *n-p-n* transistor in a common-emitter configuration. Show these characteristics graphically. Explain how current amplification factor of the transistor is calculated using output characteristics.

1+1+2+1

Or

Explain why photodiode is preferably operated under reverse bias? Give two simple applications of a photodiode with justification.

3+2

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