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PHYSICS

(Theory)

Full Marks : 70

Time : 3 hours

The figures in the margin indicate full marks for the questions

General Instructions :

(i) There are **31** questions in all. All questions are compulsory.

(ii) This question paper has four Sections : Section—A (Part—I & Part—II), Section—B, Section—C and Section—D.

(iii) Section—A (Part—I) contains five multiple choice questions of *1* mark each and Section—A (Part—II) contains five questions of *1* mark each. Section—B contains nine questions of *2* marks each, Section—C contains nine questions of *3* marks each and Section—D contains three questions of *5* marks each.

(iv) There is no overall choice. However, internal choices have been provided in one question of *1* mark, three questions of 2 marks, six questions of *3* marks and all three questions of *5* marks weightage. You have to attempt only one of the choices in such questions.

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(**2**)

(v) You may use the following values of physical constants, wherever necessary :

$$c = 3 \times 10^8 \text{ m/s}$$

$$h = 6 \cdot 63 \times 10^{-34} \text{ J-s}$$

$$e = 1 \cdot 6 \times 10^{-19} \text{ C}$$

$$\mu_0 = 4\pi \times 10^{-7} \text{ T m A}^{-1}$$

$$\varepsilon_0 = 8 \cdot 854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$$

$$m_e = 9 \cdot 1 \times 10^{-31} \text{ kg}$$

Mass of neutron $= 1 \cdot 675 \times 10^{-27}$ kg

Mass of proton $= 1 \cdot 673 \times 10^{-27}$ kg

SECTION—A

PART—I

(Multiple choice type questions)

Choose the correct option from the following : 1×5=5

1. For sustained interference of light, we must have

(A) two real monochromatic sources of same wavelength

(B) two real white sources

(C) two virtual sources obtained from a single monochromatic source

(D) two virtual white sources 1

(3)

2. In terms of susceptibility χ, a material is diamagnetic if

   (A) χ is negative

   (B) χ is positive and small

   (C) χ is large and positive

   (D) χ is zero   1

3. The work function of cesium is 2·14 eV. The threshold frequency for cesium is

   (A) $8 \cdot 15 \times 10^{13}$ Hz

   (B) $5 \cdot 16 \times 10^{14}$ Hz

   (C) $7 \cdot 12 \times 10^{12}$ Hz

   (D) $9 \cdot 16 \times 10^{15}$ Hz   1

4. Optical fibres are based on the phenomenon of

   (A) reflection

   (B) refraction

   (C) dispersion

   (D) total internal reflection   1

5. The magnitude of induced e.m.f. in a coil of inductance 1 mH in which a current is changing from 0·1 A to 2·1 A in 0·01 sec is

   (A) 0·02 V

   (B) 0·2 V

   (C) 2 V

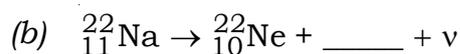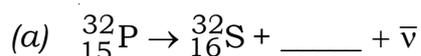   (D) 20 V   1

(4)

PART—II

(Very short answer type questions)

Answer each of the following questions in *1* sentence/step :

$1 \times 5 = 5$

6. The resistance of a given carbon resistor is $2 \cdot 4 \times 10^{6} \, \Omega \pm 5\%$. What is the sequence of colours on the resistor?   1

7. Complete the following nuclear reaction :   ½+½=1

   (a) $^{32}_{15}\text{P} \rightarrow \, ^{32}_{16}\text{S} + \underline{\hspace{1cm}} + \bar{\nu}$

   (b) $^{22}_{11}\text{Na} \rightarrow \, ^{22}_{10}\text{Ne} + \underline{\hspace{1cm}} + \nu$

8. In passing through a refracting prism, which component colour of white light bends the most? Write the equation for the speed of electromagnetic waves in terms of ε_0 and μ_0.   1

9. What is an LED?   1

10.   *Either*

   Unpolarized light is incident on a plane glass surface of $\mu = 1 \cdot 5$. What should be the angle of incidence so that the reflected and refracted rays are perpendicular to each other?   1

   Or

   Two slits are made 1 mm apart and the screen is placed 1 m away.

   What is the fringe separation when light of wavelength 500 nm is used?   1

(5)

SECTION—B

(Short answer type–I questions)

Answer each of the following questions within *20* to *30* words,
wherever applicable :   2×9=18

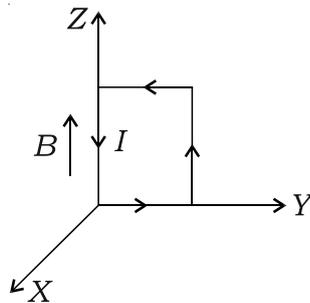**11.** State Biot-Savart law. Write the equation in vector
form.   1+1=2

12.   *Either*

A uniform magnetic field of 3000 G is established along
the positive Z-direction.

A rectangular loop of side 10 cm and 5 cm carries a
current of 12 A.

What is the torque acting on the loop shown in the
figure? (Use $1\,G = 10^{-4}$ T)   2
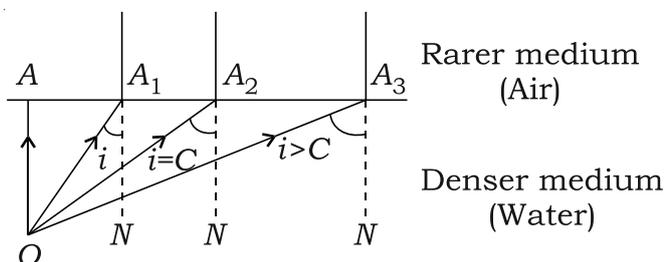

                        Or

Consider a uniform electric field $E = 3 \times 10^3$ NC^{-1}, acting
along *x*-axis.

(a) What is the flux through a square of side 10 cm
whose plane is parallel to *Y-Z* plane?

(b) What is the flux through the same square if the normal to its plane makes a 60° angle with the *x*-axis?   1+1=2

13. Complete the ray diagram for the incident rays OA, OA_1, OA_2, OA_3.   2

14.   *Either*

Define half-life of a radioactive substance.

Write the expression for it.   1+1=2

Or

What is mass defect?

Write the expression for the mass defect of a nucleus of mass M, mass number A and atomic number Z.   1+1=2

15. What are polar and non-polar dielectrics?   1+1=2

16. Explain briefly the blue colour of the sky on the basis of Rayleigh scattering.   2

17. Define the terms magnetic declination and inclination or dip.   1+1=2

(7)

18. How are X-rays generated? What is the wavelength range of X-rays? Mention one use of X-rays. $1+\frac{1}{2}+\frac{1}{2}=2$

19. *Either*

Draw a properly labelled diagram showing the main components of an AC generator. 2

Or

What are Eddy currents? How can they be minimised?
$1+1=2$

SECTION—C

(Short answer type–II questions)

Answer each of the following questions within *30* to *40* words, wherever applicable : $3\times9=27$

20. *Either*

Derive an expression for the mutual inductance of two long co-axial solenoids. 3

Or

State Lenz's law.

Show that Lenz's law is a consequence of law of conservation of energy. $1+2=3$

21. *Either*

What are extrinsic semiconductors? Citing suitable examples, explain how *p*-type and *n*-type semi-conductors are obtained. $1+1+1=3$

Or

Explain the terms depletion layer and potential barrier for a *p-n* junction diode.

What happens to the width of the depletion layer when the junction is under forward bias and reverse bias?

1+1+1=3

22. *Either*

With suitable circuit diagram, derive the required expression for the value of shunt, to convert a galvanometer into an ammeter.

A galvanometer of resistance $10\,\Omega$ gives full-scale deflection for a current of 4 mA. How can it be converted into an ammeter of range 0 to 5 A? 2+1=3
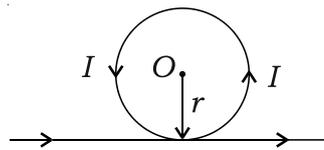
Or

State Ampere's circuital law.

A part of infinite long wire carrying current *I* is bent into a circle of radius *r* as shown in the figure. Calculate the magnetic field at the centre of the circular loop. 1+2=3

23. *Either*

Obtain an expression for the torque on a rectangular loop placed in a uniform magnetic field. 3

Or

Obtain an expression for the magnetic dipole moment of a revolving electron. 3

24. Prove that

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$$

when refraction takes place for a ray of light travelling from rarer medium to denser medium at a convex spherical refracting surface.

(n_1 and n_2 are the refractive indices of rarer and denser medium) 3

25. *Either*

What is resonance in a series LCR circuit?

Write an expression for the resonant frequency for the same circuit. Also draw a resonance curve in LCR circuit for at least two different values of resistance *R*.   1+1+1=3

Or

What is a transformer? Explain the theory and working of a transformer.   1+2=3

26. *Either*

What is a rectifier? Explain with circuit diagram the working of a full-wave rectifier.   1+2=3

Or

Explain with circuit diagram, how a Zener diode can function as a voltage regulator.   1+2=3

27. Deduce the equation for the torque acting on an electric dipole, placed in a uniform electric field.   3

28. With regards to the study of photoelectric effect, explain the following terms briefly :

(a) Work function

(b) Cut-off or stopping potential

Also draw a graph showing variation of photoelectric current with collector plate potential for incident radiation of different frequency but same intensity.

1+1+1=3

SECTION—D

(Long answer type questions)

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

29. *Either*

State Huygen's principle for wave theory of light. Using Huygen's principle, derive the laws of refraction for plane waves. 2+3=5

Or

What are coherent sources? Establish the conditions for constructive and destructive super position of waves emitted by coherent sources. 1+4=5

30. *Either*

State Gauss's law.

Using Gauss's law, derive the equation for the electric field intensity at a point due to an infinitely long straight uniformly charged wire. 1+4=5

Or

Derive the equation for the electric field intensity at a point on the equatorial line of a short electric dipole. Also write the equation in vector form. 4+1=5

31. *Either*

State Bohr's postulates for hydrogen atom.

Using Bohr's postulate, derive the expression for the energy of an electron in any orbit of the hydrogen atom.

2+3=5

Or

Draw the energy-level diagram for the hydrogen atom.

Using equation for the energy of an electron in the *n*th orbit of hydrogen atom, calculate the energy required to excite an electron from ground state to—

(a) first excited state;

(b) second excited state.

Also find the value of the kinetic energy and potential energy of the electron in the first excited state. 2+2+1=5

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