

**2 0 2 4**

**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 and 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 three questions of 1 mark, four questions of 2 marks, five questions of 3 marks and all the three questions of 5 marks weightage. You have to attempt only one of the choices in such questions.

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

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

$$h = 6.63 \times 10^{-34} \text{ J-s}$$

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

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

$$\mu_0 = 8.854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$$

$$m_e = 9.1 \times 10^{-31} \text{ kg}$$

$$\text{Mass of neutron} = 1.00867 \text{ amu} = 1.675 \times 10^{-27} \text{ kg}$$

$$\text{Mass of proton} = 1.00728 \text{ amu} = 1.673 \times 10^{-27} \text{ kg}$$

$$\text{Mass of } \alpha\text{-particle} = 4.00152 \text{ amu} = 6.646 \times 10^{-27} \text{ kg}$$

## SECTION—A

### PART—I

( Multiple choice type questions )

Choose and write the correct option for the following : 1×5=5

1. The core in transformers and other electromagnetic devices is laminated, so as to
- (a) increase the magnetic field
  - (b) increase the magnetic flux
  - (c) reduce the magnetism in the core
  - (d) reduce the eddy current losses in the core
- 1

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2. In Young's double-slit experiment, a monochromatic ray of light of wavelength  $5 \times 10^{-5}$  cm falls on double-slit of slit width 0.025 mm. If the phenomenon of interference is observed on the screen at a distance of 5 cm, the fringe width becomes

(a) 0.1 mm  
(b) 1 mm  
(c) 0.01 mm  
(d) None of the above

1

3. A short bar magnet placed with its axis at  $30^\circ$  with an external magnetic field of 800 G experiences a torque of 0.016 N-m. What is the magnetic moment of the magnet?

(a)  $0.40 \text{ A-m}^2$   
(b)  $0.004 \text{ A-m}^2$   
(c)  $0.80 \text{ A-m}^2$   
(d)  $0.02 \text{ A-m}^2$

1

4. If  $\vec{E}$  and  $\vec{B}$  represent electric and magnetic field vectors of the electromagnetic waves, then the direction of propagation of the electromagnetic waves is that of

(a)  $\vec{E}$   
(b)  $\vec{B}$   
(c)  $\vec{E} \times \vec{B}$   
(d)  $\vec{E} \cdot \vec{B}$

1

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5. *n*-type semiconductor is obtained by doping the intrinsic semiconductor with

- (a) trivalent material
- (b) conductor
- (c) insulator
- (d) pentavalent material

1

PART—II

( Very short answer type questions )

Answer each of the following questions in 1 sentence/step : 1×5=5

6. *Either*

If an intrinsic semiconductor is doped with a monovalent material, what type of extrinsic semiconductor will we get?

1

*Or*

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

1

7. What is meant by the term doping?

1

8. *Either*

Why is there no photoelectric current at frequencies below threshold frequency?

1

*Or*

Write down the Einstein photoelectric equation.

1

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9. *Either*

A semi-circular arc of radius 20 cm carries a current of 10 A. What is the magnitude of the magnetic field at the centre of the arc? 1

*Or*

A galvanometer with a coil of resistance 12  $\Omega$  shows full-scale deflection for a current 2.5 mA. How will you convert the galvanometer into an ammeter of range 0 to 7.5 A? 1

10. Arrange the following electromagnetic radiations in descending order of their frequencies : 1

X-rays, Visible light, Ultraviolet rays, Radio waves

### SECTION—B

( Short answer type-I questions )

Answer each of the following questions within 20 to 30 words, wherever applicable :  $2 \times 9 = 18$

11. *Either*

What is nuclear fusion? Write the underlying principle of atom bomb.  $1+1=2$

*Or*

Write two defects of Rutherford's atomic model. 2

12. *Either*

The radii of curvature of a double-convex lens are 15 cm and 30 cm and its refractive index is 1.5. Calculate its power. 2

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*Or*

A convex lens of focal length 30 cm and a concave lens of focal length 60 cm are placed in contact. Find the power of the combination. 2

13. An iron-cored solenoid and a bulb are connected to an a.c. source. If the iron core is removed from the solenoid, the brightness of the bulb decreases. Why? 2

14. *Either*

State two conditions to be fulfilled by a ray of light in the phenomenon of total internal reflection. Name one technological application of total internal reflection. 2

*Or*

State two conditions, which must be satisfied for two light sources to be coherent. Can two independent sources of light be coherent? 2

15. Show that the de Broglie wavelength of an electron of kinetic energy  $K$  is given by  $\frac{h}{\sqrt{2mK}}$ , where  $m$  is the mass of electron and  $h$  is Planck's constant. 2

16. *Either*

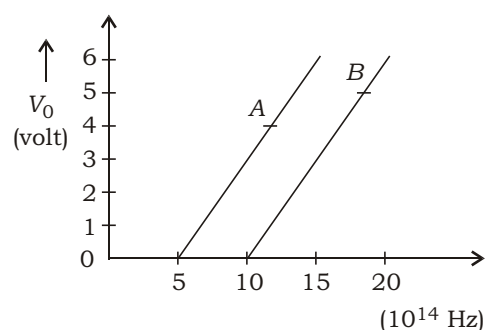
The ground state energy of H-atom is 13.6 eV. What are the kinetic and potential energies of the electron in this state? 2

*Or*

A hydrogen atom initially in the ground level absorbs a photon which excites it to the  $n = 4$  level. Determine the wavelength and frequency of the photon. 2

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17. An  $n$ -type semiconductor has a large number of electrons but still it is electrically neutral. Explain the reason. 2
18. A student performs an experiment on photoelectric effect using two materials  $A$  and  $B$ . A plot of stopping potential ( $V_0$ ) and frequency ( ) is given in the figure :



Which material,  $A$  or  $B$ , has greater work function ( )? Justify your answer. 2

19. Write Biot-Savart law in vector form. What is the limitation of Biot-Savart law? 1+1=2

### SECTION—C

( Short answer type—II questions )

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

20. *Either*

Draw a ray diagram of an astronomical telescope showing the final image at infinity and write the expression of its magnifying power. 3

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*Or*

With the help of a ray diagram, show that the total deviation of a ray of light passing through a glass prism is given by  $i + e - A$ , where the symbols used carry usual meanings.

3

**21.**

*Either*

Distinguish between conductors, semi-conductors and insulators on the basis of band theory of solids. 1+1+1=3

*Or*

Draw a circuit diagram of a full-wave rectifier. Explain its working and show the input, output waveforms. 1+1+1=3

**22.** State Ampere's circuital law. Using this law, obtain the expression for the magnetic field near an infinitely long current-carrying wire. 1+2=3

**23.**

*Either*

Write the expression of Lorentz force. Obtain the force on a current-carrying conductor in a uniform magnetic field. 1+2=3

*Or*

What is a magnetic moment? Obtain the magnetic moment of a revolving electron around the nucleus. 1+2=3

**24.** Give one point of difference between the e.m.f. and the terminal potential difference of a cell. Show that the internal resistance of a cell is  $r = \frac{E - V}{V} R$ , where  $E$  and  $V$  are the e.m.f. and potential difference of the cell and  $R$  is the load resistance. 1+2=3



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25.

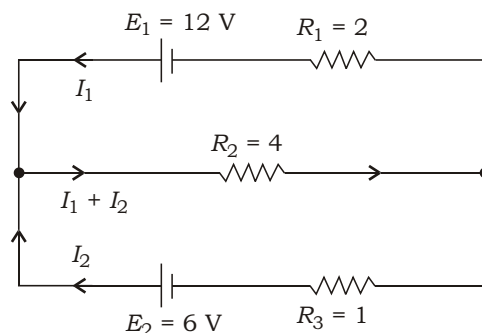
*Either*

Show that the torque acting on an electric dipole placed in a uniform electric field  $\vec{E}$  is  $\vec{p} \times \vec{E}$ , where  $\vec{p}$  and  $\vec{\tau}$  represent the dipole moment and torque respectively. 3

*Or*

What is resistance of a resistor? Show that the equivalent resistance of three resistors connected in series is equal to the sum of the resistances of the individual resistors. 1+2=3

26. Using Kirchhoff's laws in the electrical network, calculate  $I_1$ ,  $I_2$  and the rate of dissipation of energy in  $R_2$  : 1+1+1=3



27.

*Either*

The relative magnetic permeability of a magnetic material is 800. Identify the type of the magnetic material and state two of its properties. 1+2=3

*Or*

What are magnetic field lines? Can two magnetic field lines intersect? Justify your answer. 1+1+1=3

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- 28.** What holds nucleons together in the nucleus? Calculate the binding energy of an  $\alpha$ -particle. 1+2=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*

What is electric flux? Using Gauss' law, find the electric field due to a uniformly charged thin spherical shell of uniform surface charge density (  $\sigma$  ) at a point (a) inside the shell and (b) outside the shell. 1+2+2=5

*Or*

What are polar and non-polar molecules? Deduce an expression for the capacitance of a capacitor with a dielectric substance of dielectric constant  $K$  and thickness  $t$  such that the thickness is less than the separation between the plates ( $d$ ). 1+1+3=5

**30.**

*Either*

Give the construction and theory of an a.c. generator. 2+3=5

*Or*

Derive an expression for average power in  $L$ - $C$ - $R$  circuit connected to an a.c. supply. What is wattless current? 4+1=5

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**31.**

*Either*

What is a wavefront? Establish the laws of refraction on the basis of Huygen's principle. 1+4=5

*Or*

What is interference of light waves? Deduce analytically the conditions for constructive and destructive interference of two coherent light waves. 1+2+2=5

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