Series GEFH1/3

SET ~ 1

प्रश्न-पत्र कोड
Q.P. Code 55/3/1

रोल नं.
Roll No.

परीक्षार्थी प्रश्न-पत्र कोड को उत्तर-पुस्तिका के मुख-पृष्ठ पर अवश्य लिखें ।
Candidates must write the Q.P. Code on the title page of the answer-book. *

भौतिक विज्ञान (सैद्धान्तिक)
PHYSICS (Theory)

निर्धारित समय : 3 घण्टे *अधिकतम अंक : 70*

Time allowed : 3 hours *Maximum Marks : 70*

नोट / NOTE :

(i) कृपया जाँच कर लें कि इस प्रश्न-पत्र में मुद्रित पृष्ठ **23** हैं ।
Please check that this question paper contains **23** printed pages.

(ii) प्रश्न-पत्र में दाहिने हाथ की ओर दिए गए प्रश्न-पत्र कोड को परीक्षार्थी उत्तर-पुस्तिका के मुख-पृष्ठ पर लिखें ।
Q.P. Code given on the right hand side of the question paper should be written on the title page of the answer-book by the candidate.

(iii) कृपया जाँच कर लें कि इस प्रश्न-पत्र में **35** प्रश्न हैं ।
Please check that this question paper contains **35** questions.

(iv) **कृपया प्रश्न का उत्तर लिखना शुरू करने से पहले, उत्तर-पुस्तिका में प्रश्न का क्रमांक अवश्य लिखें ।**
Please write down the serial number of the question in the answer-book before attempting it.

(v) इस प्रश्न-पत्र को पढ़ने के लिए 15 मिनट का समय दिया गया है । प्रश्न-पत्र का वितरण पूर्वाह्न में 10.15 बजे किया जाएगा । 10.15 बजे से 10.30 बजे तक छात्र केवल प्रश्न-पत्र को पढ़ेंगे और इस अवधि के दौरान वे उत्तर-पुस्तिका पर कोई उत्तर नहीं लिखेंगे ।
15 minute time has been allotted to read this question paper. The question paper will be distributed at 10.15 a.m. From 10.15 a.m. to 10.30 a.m., the students will read the question paper only and will not write any answer on the answer-book during this period.

General Instructions :

Read the following instructions very carefully and strictly follow them :

(i) *This question paper contains **35** questions. **All** questions are **compulsory**.*

(ii) *This question paper is divided into **five** Sections – **A**, **B, C, D** and **E**.*

(iii) *In **Section A** – Questions no. **1** to **18** are Multiple Choice (MCQ) type questions, carrying **1** mark each.*

(iv) *In **Section B** – Questions no. **19** to **25** are Very Short Answer (VSA) type questions, carrying **2** marks each.*

(v) *In **Section C** – Questions no. **26** to **30** are Short Answer (SA) type questions, carrying **3** marks each.*

(vi) *In **Section D** – Questions no. **31** to **33** are Long Answer (LA) type questions carrying **5** marks each.*

(vii) *In **Section E** – Questions no. **34** and **35** are case-based questions carrying **4** marks each.*

(viii) *There is no overall choice. However, an internal choice has been provided in 2 questions in Section B, 2 questions in Section C, 3 questions in Section D and 2 questions in Section E.*

(ix) *Use of calculators is **not** allowed.*

Use the following values of physical constants, if required :

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

$h = 6{\cdot}63 \times 10^{-34}$ Js

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

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

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

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N m^2 C^{-2}

Mass of electron $(m_e) = 9{\cdot}1 \times 10^{-31}$ kg

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

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

Avogadro's number $= 6{\cdot}023 \times 10^{23}$ per gram mole

Boltzmann constant $= 1{\cdot}38 \times 10^{-23}$ JK^{-1}

SECTION A

1. An electron experiences a force $(1{\cdot}6 \times 10^{-16}\ \text{N})\ \hat{i}$ in an electric field $\vec{E}$. The electric field $\vec{E}$ is :

(a) $(1{\cdot}0 \times 10^{3}\ \frac{\text{N}}{\text{C}})\ \hat{i}$ (b) $-(1{\cdot}0 \times 10^{3}\ \frac{\text{N}}{\text{C}})\ \hat{i}$

(c) $(1{\cdot}0 \times 10^{-3}\ \frac{\text{N}}{\text{C}})\ \hat{i}$ (d) $-(1{\cdot}0 \times 10^{-3}\ \frac{\text{N}}{\text{C}})\ \hat{i}$

2. Which one of the following is ***not*** a scalar quantity ?

(a) Electric field (b) Voltage

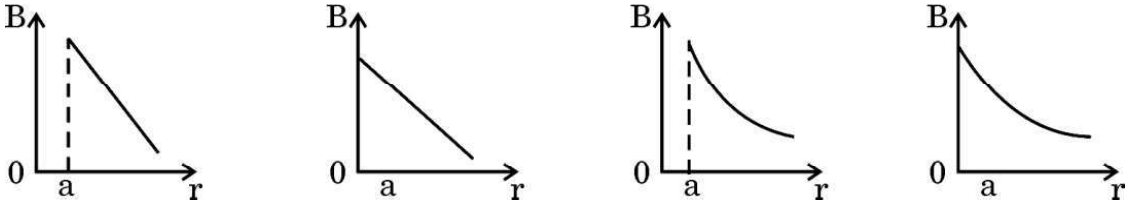
(c) Resistivity (d) Power

3. The current density due to drift of electrons in a conductor is given by : (symbols have their usual meanings)

(a) $n\ e\ A\ v_d$ (b) $\frac{n\ A\ v_d}{e}$

(c) $\frac{n\ v_d}{e\ A}$ (d) $n\ e\ v_d$

4. Which of the following graphs correctly represents the variation of the magnitude of the magnetic field outside a straight infinite current carrying wire of radius 'a', as a function of distance 'r' from the centre of the wire ?



(a) (b) (c) (d)

5. A particle of mass m and charge q moving with a uniform velocity $\vec{v} = v_{0x}\ \hat{i} + v_{0y}\ \hat{j}$ enters a region with a magnetic field $\vec{B} = B_0\ \hat{j}$. After some time, an electric field $\vec{E} = E_0\ \hat{j}$ is also switched on in the region. The resulting path described by the particle will be :

(a) a circle in x-z plane

(b) a parabola in x-y plane

(c) a helix with constant pitch

(d) a helix with increasing pitch

6. An inductor, a capacitor and a resistor are connected in series across an ac source of voltage. If the frequency of the source is decreased gradually, the reactance of :

(a) both the inductor and the capacitor decreases.

(b) inductor decreases and the capacitor increases.

(c) both the inductor and the capacitor increases.

(d) inductor increases and the capacitor decreases.

7. The electromagnetic radiations used to kill germs in water purifiers are called :

(a) Infrared waves

(b) X-rays

(c) Gamma rays

(d) Ultraviolet rays

8. In the wave picture of light, the intensity I of light is related to the amplitude A of the wave as :

(a) $I \propto \sqrt{A}$

(b) $I \propto A$

(c) $I \propto A^2$

(d) $I \propto \frac{1}{A^2}$

9. In a single-slit diffraction experiment, the width of the slit is halved. The width of the central maximum, in the diffraction pattern, will become :

(a) half

(b) twice

(c) four times

(d) one-fourth

10. A graph is plotted between the stopping potential (on y-axis) and the frequency of incident radiation (on x-axis) for a metal. The product of the slope of the straight line obtained and the magnitude of charge on an electron is equal to :

(a) h

(b) $\frac{h}{c}$

(c) $\frac{2h}{c}$

(d) $\frac{h}{2c}$

11. Light of frequency $6{\cdot}4 \times 10^{14}$ Hz is incident on a metal of work function 2·14 eV. The maximum kinetic energy of the emitted electrons is about :

(a) 0·25 eV

(b) 0·51 eV

(c) 1·02 eV

(d) 0·10 eV

12. The ratio of maximum frequency and minimum frequency of light emitted in Balmer series of hydrogen spectrum, in Bohr's model is :

(a) $\frac{11}{9}$

(b) $\frac{9}{5}$

(c) $\frac{11}{7}$

(d) $\frac{16}{7}$

13. At a certain temperature in an intrinsic semiconductor, the electrons and holes concentration is $1{\cdot}5 \times 10^{16}$ m^{-3}. When it is doped with a trivalent dopant, hole concentration increases to $4{\cdot}5 \times 10^{22}$ m^{-3}. In the doped semiconductor, the concentration of electrons (n_e) will be :

(a) 3×10^{6} m^{-3}

(b) 5×10^{7} m^{-3}

(c) 5×10^{9} m^{-3}

(d) $6{\cdot}75 \times 10^{38}$ m^{-3}

14. If a p-n junction diode is reverse biased,

(a) the potential barrier is lowered.

(b) the potential barrier remains unaffected.

(c) the potential barrier is raised.

(d) the current is mainly due to majority carriers.

15. A voltage signal is described by :

$$v = V_0 \quad \text{for } 0 \le t \le \frac{T}{2}$$

$$= 0 \quad \text{for } \frac{T}{2} \le t \le T$$

for a cycle. Its rms value is :

(a) $\frac{V_0}{\sqrt{2}}$

(b) V_0

(c) $\frac{V_0}{2}$

(d) $\sqrt{2}\ V_0$

*Questions number **16** to **18** are Assertion (A) and Reason (R) type questions. Two statements are given — one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer from the codes (a), (b), (c) and (d) as given below.*

(a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(b) Both Assertion (A) and Reason (R) are true, but Reason (R) is ***not*** the correct explanation of the Assertion (A).

(c) Assertion (A) is true, but Reason (R) is false.

(d) Assertion (A) is false and Reason (R) is also false.

16. *Assertion (A) :* The internal resistance of a cell is constant.

Reason (R) : Ionic concentration of the electrolyte remains same during use of a cell.

17. *Assertion (A) :* When radius of a circular loop carrying a steady current is doubled, its magnetic moment becomes four times.

Reason (R): The magnetic moment of a circular loop carrying a steady current is proportional to the area of the loop.

18. *Assertion (A):* The nucleus ${}^{7}_{3}\mathrm{X}$ is more stable than the nucleus ${}^{4}_{3}\mathrm{Y}$.

Reason (R): ${}^{7}_{3}\mathrm{X}$ contains more number of protons.

SECTION B

19. A wire of length l is in the form of a circular loop A of one turn. This loop is reshaped into loop B of three turns. Find the ratio of the magnetic fields at the centres of loop A and loop B for the same current through them. *2*

20. What is meant by the term 'displacement current' ? Briefly explain how this current is different from a conduction current. *2*

21. (a) State Huygens' principle. How did Huygens explain the absence of the backwave ? *2*

OR

(b) Use Huygens' principle to show reflection/refraction of a plane wave by (i) concave mirror, and (ii) a convex lens. *2*

22. The refractive indices of two media A and B are 2 and $\sqrt{2}$ respectively. What is the critical angle for their interface ? *2*

23. (a) Draw a graph showing the variation of binding energy per nucleon as a function of mass number A. The binding energy per nucleon for heavy nuclei (A > 170) decreases with the increase in mass number. Explain. *2*

OR

(b) Using Bohr's postulates, obtain the expression for radius of n^{th} stable orbit in a hydrogen atom. *2*

24. Explain the roles of diffusion current and drift current in the formation of the depletion layer in a p-n junction diode. *2*

25. Explain the property of a p-n junction which makes it suitable for rectifying alternating voltages. Differentiate between a half-wave and a full-wave rectifier. *2*

SECTION C

26. A potential difference V is applied across a conductor of length l and uniform cross-section area A. How will the (i) electric field E, (ii) drift velocity v_d, and (iii) current density j be affected when (a) V is doubled and (b) l is halved (keeping other factors constant) ? *3*

27. What is meant by the term 'mutual inductance' of a pair of coils ? Obtain an expression for the mutual inductance of two long coaxial solenoids, each of length l but having different number of turns N_1 and N_2 and radii r_1 and r_2 ($r_2 > r_1$). *3*

28. (a) An ac source $v = v_m \sin \omega t$ is connected across an ideal capacitor. Derive the expression for the (i) current flowing in the circuit, and (ii) reactance of the capacitor. Plot a graph of current i versus ωt. *3*

OR

(b) A series combination of an inductor L, a capacitor C and a resistor R is connected across an ac source of voltage in a circuit. Obtain an expression for the average power consumed by the circuit. Find power factor for (i) purely inductive circuit, and (ii) purely resistive circuit. *3*

29. Calculate the wavelength of de Broglie waves associated with a proton having $\left(\frac{500}{1{\cdot}673}\right)$ eV energy. How will the wavelength be affected for an alpha particle having the same energy ? *3*

30. (a) (i) Prove that the nuclear density is same for all nuclei.

(ii) Draw a plot of potential energy of a pair of nucleons as a function of their separation. Draw two inferences from this plot. *3*

OR

(b) (i) Draw a graph to show the variation of the number of scattered particles detected (N) in Geiger-Marsden experiment as a function of scattering angle (θ).

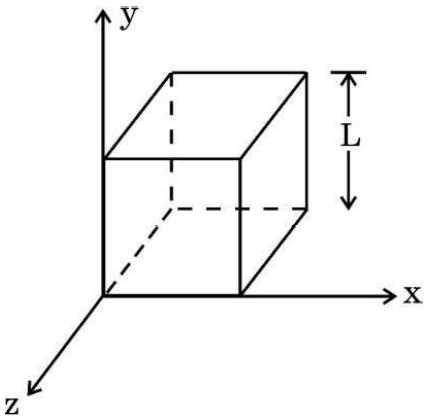
(ii) Discuss briefly two conclusions that can be drawn from this graph and how they lead to the discovery of nucleus in an atom. *3*

SECTION D

31. (a) (i) Define electric flux and write its SI unit.

(ii) Use Gauss' law to obtain the expression for the electric field due to a uniformly charged infinite plane sheet.

(iii) A cube of side L is kept in space, as shown in the figure. An electric field $\vec{E} = (Ax + B)\,\hat{i}\ \frac{N}{C}$ exists in the region. Find the net charge enclosed by the cube. *5*



OR

(b) (i) Define electric potential at a point and write its SI unit.

(ii) Two capacitors are connected in series. Derive an expression of the equivalent capacitance of the combination.

(iii) Two point charges + q and – q are located at points (3a, 0) and (0, 4a) respectively in x-y plane. A third charge Q is kept at the origin. Find the value of Q, in terms of q and a, so that the electrostatic potential energy of the system is zero. *5*

32. (a) (i) Write the principle and explain the working of a moving coil galvanometer. A galvanometer as such cannot be used to measure the current in a circuit. Why ?

(ii) Why is the magnetic field made radial in a moving coil galvanometer ? How is it achieved ? *5*

OR

(b) (i) Derive an expression for magnetic field on the axis of a current carrying circular loop.

(ii) Write any two points of difference between a diamagnetic and a paramagnetic substance. *5*

33. (a) (i) Draw a ray diagram showing the formation of a real image of an object placed at a distance 'u' in front of a concave mirror of radius of curvature 'R'. Hence, obtain the relation for the image distance 'v' in terms of u and R.

(ii) A 1·8 m tall person stands in front of a convex lens of focal length 1 m, at a distance of 5 m. Find the position and height of the image formed. *5*

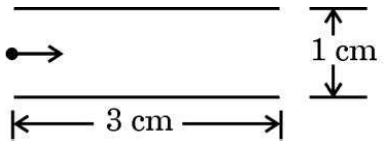
OR

(b) (i) Draw a ray diagram showing refraction of a ray of light through a triangular glass prism. Hence, obtain the relation for the refractive index (μ) in terms of angle of prism (A) and angle of minimum deviation (δ_m).

(ii) The radii of curvature of the two surfaces of a concave lens are 20 cm each. Find the refractive index of the material of the lens if its power is – 5·0 D. *5*

SECTION E

34. A beam of electrons moving horizontally with a velocity of 3×10^7 m/s enters a region between two plates as shown in the figure. A suitable potential difference is applied across the plates such that the electron beam just strikes the edge of the lower plate.



Answer the following questions based on the above :

(a) How long does an electron take to strike the edge ? *1*

(b) What is the shape of the path followed by the electron and why ? *1*

(c) Find the potential difference applied. *2*

OR

(c) Find the magnitude and direction of the magnetic field which should be created in the space between the plates so that the electron beam goes straight undeviated. *2*

35. Diffraction of light is bending of light around the corners of an object whose size is comparable with the wavelength of light. Diffraction actually defines the limits of ray optics. This limit for optical instruments is set by the wavelength of light. An experimental arrangement is set up to observe the diffraction pattern due to a single slit.

Answer the following questions based on the above :

(a) How will the width of central maximum be affected if the wavelength of light is increased ? *1*

(b) Under what condition is the first minimum obtained ? *1*

(c) Write two points of difference between interference and diffraction patterns. *2*

OR

(c) Two students are separated by a 7 m partition wall in a room 10 m high. If both light and sound waves can bend around obstacles, how is it that the students are unable to see each other even though they can converse easily ? *2*