Series SR5QP/5

रोल नं.
Roll No. 1 9 6 0 9 0 9 2

Set-3

प्रश्न-पत्र कोड
Q.P. Code **55/5/3**

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)

[redacted]

निर्धारित समय : 3 घण्टे
Time allowed : 3 hours

अधिकतम अंक : 70
Maximum Marks : 70

नोट	NOTE
(I) कृपया जाँच कर लें कि इस प्रश्न-पत्र में मुद्रित पृष्ठ **23** हैं ।	(I) Please check that this question paper contains **23** printed pages.
(II) कृपया जाँच कर लें कि इस प्रश्न-पत्र में **33** प्रश्न हैं ।	(II) Please check that this question paper contains **33** questions.
(III) प्रश्न-पत्र में दाहिने हाथ की ओर दिए गए प्रश्न-पत्र कोड को परीक्षार्थी उत्तर-पुस्तिका के मुख-पृष्ठ पर लिखें ।	(III) 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.
(IV) **कृपया प्रश्न का उत्तर लिखना शुरू करने से पहले, उत्तर-पुस्तिका में प्रश्न का क्रमांक अवश्य लिखें ।**	(IV) **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 परीक्षार्थी केवल प्रश्न-पत्र को पढ़ेंगे और इस अवधि के दौरान वे उत्तर-पुस्तिका पर कोई उत्तर नहीं लिखेंगे ।	(V) 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 candidates 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 follow them :

(i) *This question paper contains* ***33*** *questions.* ***All*** *questions are compulsory.*

(ii) *Question paper is divided into* ***FIVE*** *sections – Section* ***A, B, C, D*** *and* ***E****.*

(iii) *In* ***Section A :*** *Question number* ***1*** *to* ***16*** *are Multiple Choice (MCQ) type questions carrying* ***1*** *mark each.*

(iv) *In* ***Section B :*** *Question number* ***17*** *to* ***21*** *are Very Short Answer (VSA) type questions carrying* ***2*** *marks each.*

(v) *In* ***Section C :*** *Question number* ***22*** *to* ***28*** *are Short Answer (SA) type questions carrying* ***3*** *marks each.*

(vi) *In* ***Section D :*** *Question number* ***29*** *&* ***30*** *are Long Answer (LA) type questions carrying* ***4*** *marks each.*

(vii) *In* ***Section E :*** *Question number* ***31*** *to* ***33*** *are Case-Based questions carrying* ***5*** *marks each.*

(viii) *There is no overall choice. However, an internal choice has been provided in* ***1*** *question in Section–****B****,* ***1*** *question in Section–****C****,* ***2*** *questions in Section–****D*** *and* ***3*** *questions in Section–****E****.*

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

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

$h = 6.63 \times 10^{-34}$ Js

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

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

$\varepsilon_0 = 8.854 \times 10^{-12}$ 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) = 9.1×10^{-31} kg

Mass of neutron = 1.675×10^{-27} kg

Mass of proton = 1.673×10^{-27} kg

Avogadro's number = 6.023×10^{23} per gram mole

Boltzmann constant = 1.38×10^{-23} JK^{-1}

SECTION – A

1. A heater coil rated as (P, V) is cut into two equal parts. One of the parts is then connected to a battery of V volt. The power consumed by it will be

(A) P

(B) $\frac{P}{2}$

(C) $\frac{P}{4}$

(D) 2P

2. Two insulated concentric coils, each of radius R, placed at right angles to each other, carry currents I and $\sqrt{3}$ I respectively. The magnitude of the net magnetic field at their common centre will be

(A) $\frac{\mu_o I}{R}$

(B) $\frac{\mu_o I}{2R}$

(C) $\frac{\mu_o I}{4R}$

(D) $\frac{2\mu_o I}{R}$

3. Which of the following material has its magnetic susceptibility x in the range $0 < x < \varepsilon$, where ε is positive and small ?

(A) Aluminium

(B) Water

(C) Gadolinium

(D) Bismuth

4. A galvanometer of resistance 100 Ω gives full scale deflection for a current of 1.0 mA. It is converted into an ammeter of range (0 – 1A). The resistance of the ammeter will be close to

(A) 0.1 Ω

(B) 0.8 Ω

(C) 1.0 Ω

(D) 10 Ω

5. The mutual inductance of two coils, in a given orientation is 50 mH. If the current in one of the coils changes as $i = 1.0 \sin\left(100\pi t + \frac{\pi}{3}\right)$ A, the peak value of emf (in volt) induced in the other coil will be

(A) $\frac{\pi}{5}$

(B) 5π

(C) 0.5π

(D) 0.05π

6. The potential energy between two nucleons inside a nucleus is minimum at a distance of about

(A) 0.8 fm
(B) 1.6 fm
(C) 2.0 fm
(D) 2.8 fm

7. A pure Si crystal having 5×10^{28} atoms m^{-3} is dopped with 1 ppm concentration of antimony. If the concentration of holes in the doped crystal is found to be 4.5×10^9 m^{-3}, the concentration (in m^{-3}) of intrinsic charge carriers in Si crystal is about

(A) 1.2×10^{15}
(B) 1.5×10^{16}
(C) 3.0×10^{15}
(D) 2.0×10^{16}

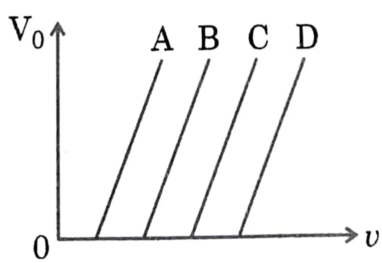
8. The energy of an electron in the ground state of hydrogen atom is –13.6 eV. The kinetic and potential energy of the electron in the first excited state will be

(A) –13.6 eV, 27.2 eV
(B) –6.8 eV, 13.6 eV
(C) 3.4 eV, –6.8 eV
(D) 6.8 eV, –3.4 eV

9. The electromagnetic waves used to purify water are

(A) Infrared rays
(B) Ultraviolet rays
(C) X-rays
(D) Gamma rays

10. The variation of the stopping potential (V_0) with the frequency (υ) of the incident radiation for four metals A, B, C and D is shown in the figure. For the same frequency of incident radiation producing photo-electrons in all metals, the kinetic energy of photo-electrons will be maximum for metal



(A) A
(B) B
(C) C
(D) D

11. The focal lengths of the objective and the eyepiece of a compound microscope are 1 cm and 2 cm respectively. If the tube length of the microscope is 10 cm, the magnification obtained by the microscope for most suitable viewing by relaxed eye is :

(A) 250 (B) 200

(C) 150 (D) 125

12. A point object is kept 60 cm in front of a spherical convex surface (n = 1.5, radius of curvature 40 cm). The image formed is

(A) real, at a distance 1.8 m from the surface.

(B) virtual, at a distance 1.8 m from the surface.

(C) real, at a distance 3.6 m from the surface.

(D) virtual, at a distance 3.6 m from the surface.

For Questions 13 to 16, two statements are given – one labelled Assertion (A) and other labelled Reason (R). Select the correct answer to these questions from the options as given below.

(A) If both Assertion (A) and Reason (R) are true and Reason (R) is correct explanation of Assertion (A).

(B) If both Assertion (A) and Reason (R) are true and Reason (R) is not the correct explanation of Assertion (A).

(C) If Assertion (A) is true but Reason (R) is false.

(D) If both Assertion (A) and Reason (R) are false.

13. **Assertion (A)** : In a Young's double-slit experiment, interference pattern is not observed when two coherent sources are infinitely close to each other.

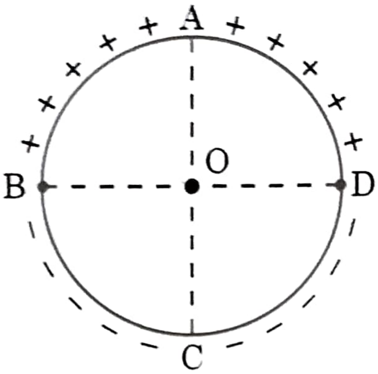
Reason (R) : The fringe width is proportional to the separation between the two sources.

14. **Assertion (A)** : An alpha particle is moving towards a gold nucleus. The impact parameter is maximum for the scattering angle of 180°.

Reason (R) : The impact parameter in an alpha particle scattering experiment does not depend upon the atomic number of the target nucleus.

15. **Assertion (A)** : Equal amount of positive and negative charges are distributed uniformly on two halves of a thin circular ring as shown in figure. The resultant electric field at the centre O of the ring is along OC.

Reason (R) : It is so because the net potential at O is not zero.



16. **Assertion (A)** : The energy of a charged particle moving in a magnetic field does not change.

Reason (R) : It is because the work done by the magnetic force on the charge moving in a magnetic field is zero.

SECTION – B

17. Derive an expression for magnetic force $\vec{F}$ acting on a straight conductor of length L carrying current I in an external magnetic field $\vec{B}$. Is it valid when the conductor is in zig-zag form ? Justify.

18. (a) Four point charges of 1 μC, –2 μC, 1 μC and –2 μC are placed at the corners A, B, C and D respectively, of a square of side 30 cm. Find the net force acting on a charge of 4 μC placed at the centre of the square.

OR

18. (b) Three point charges, 1 pC each, are kept at the vertices of an equilateral triangle of side 10 cm. Find the net electric field at the centroid of triangle.

19. A thin converging lens of focal length 10 cm is placed coaxially in contact with a thin diverging lens of focal length 15 cm. How will the combination behave ? Justify your answer.

20. Deuterium undergoes the following fusion reaction :

$$^{2}_{1}H + ^{2}_{1}H \longrightarrow ^{3}_{2}He + ^{1}_{0}n + 3.27 \text{ MeV}$$

How long an electric bulb of 200 W will glow by using the energy released in 2 g of deuterium ?

21. The electron in hydrogen atom is revolving with the speed of 2.2×10^6 m/s in an orbit of radius 0.53 Å. Calculate the initial frequency of light emitted by the electron using classical physics.

SECTION – C

22. (a) (i) State Lenz's Law. In a closed circuit, the induced current opposes the change in magnetic flux that produced it as per the law of conservation of energy. Justify.

(ii) A metal rod of length 2 m is rotated with a frequency 60 rev/s about an axis passing through its centre and perpendicular to its length. A uniform magnetic field of 2T perpendicular to its plane of rotation is switched-on in the region. Calculate the e.m.f. induced between the centre and the end of the rod.

OR

22. (b) (i) State and explain Ampere's circuital law.

(ii) Two long straight parallel wires separated by 20 cm, carry 5 A and 10 A current respectively, in the same direction. Find the magnitude and direction of the net magnetic field at a point midway between them.

23. The threshold frequency for a metal is 3.0×10^{14} Hz. A beam of frequency 9.0×10^{14} Hz is incident on the metal. Calculate (i) the work function (in eV) of the metal and (ii) the maximum speed of photoelectrons.

24. (a) Name the parts of the electromagnetic spectrum which are (i) also known as 'heat waves' and (ii) absorbed by ozone layer in the atmosphere.

(b) Write briefly one method each, of the production and detection of these radiations.

25. (a) Explain the characteristics of a p-n junction diode that makes it suitable for its use as a rectifier.

(b) With the help of a circuit diagram, explain the working of a full wave rectifier.

26. Explain the following, giving reasons :

(a) A doped semiconductor is electrically neutral.

(b) In a p-n junction under equilibrium, there is no net current.

(c) In a diode, the reverse current is practically not dependent on the applied voltage.

27. An electron is moving with a velocity $\vec{v} = \left(3 \times 10^6 \frac{m}{s}\right)\hat{i}$. It enters a region of magnetic field $\vec{B} = (91 \text{ mT})\hat{k}$.

(a) Calculate the magnetic force $\vec{F}_B$ acting on electron and the radius of its path.

(b) Trace the path described by it.

28. A potential difference of 1.0 V is applied across a conductor of length 5.0 m and area of cross-section 1.0 mm^2. When current of 4.25 A is passed through the conductor, calculate

(i) the drift speed and (ii) relaxation time, of electrons. (Given number density of electrons in the conductor, $n = 8.5 \times 10^{28}\ m^{-3}$).

SECTION – D

29. A prism is an optical medium bounded by three refracting plane surfaces. A ray of light suffers successive refractions on passing through its two surfaces and deviates by a certain angle from its original path. The refractive index of the material of the prism is given by $\mu = \sin\left(\frac{A + \delta m}{2}\right) / \sin\frac{A}{2}$. If the angle of incidence on the second surface is greater than an angle called critical angle, the ray will not be refracted from the second surface and is totally internally reflected.

(i) The critical angle for glass is θ_1 and that for water is θ_2. The critical angle for glass-water surface would be (given $_a\mu_g = 1.5$, $_a\mu_w = 1.33$)

(A) less than θ_2 (B) between θ_1 and θ_2

(C) greater than θ_2 (D) less than θ_1

(ii) When a ray of light of wavelength λ and frequency υ is refracted into a denser medium

(A) λ and υ both increase.

(B) λ increases but υ is unchanged.

(C) λ decreases but υ is unchanged.

(D) λ and υ both decrease.

(iii) (a) The critical angle for a ray of light passing from glass to water is minimum for

(A) red colour (B) blue colour

(C) yellow colour (D) violet colour

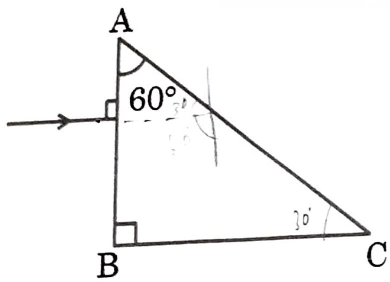
OR

(iii) (b) Three beams of red, yellow and violet colours are passed through a prism, one by one under the same condition. When the prism is in the position of minimum deviation, the angles of refraction from the second surface are r_R, r_Y and r_V respectively. Then

(A) $r_V < r_Y < r_R$ (B) $r_Y < r_R < r_V$

(C) $r_R < r_Y < r_V$ (D) $r_R = r_Y = r_V$

(iv) A ray of light is incident normally on a prism ABC of refractive index $\sqrt{2}$, as shown in figure. After it strikes face AC, it will



(A) go straight undeviated

(B) just graze along the face AC

(C) refract and go out of the prism

(D) undergo total internal reflection

30. Dielectrics play an important role in design of capacitors. The molecules of a dielectric may be polar or non-polar. When a dielectric slab is placed in an external electric field, opposite charges appear on the two surfaces of the slab perpendicular to electric field. Due to this an electric field is established inside the dielectric.

The capacitance of a capacitor is determined by the dielectric constant of the material that fills the space between the plates. Consequently, the energy storage capacity of a capacitor is also affected. Like resistors, capacitors can also be arranged in series and/or parallel.

(i) Which of the following is a polar molecule ?

(A) O_2 (B) H_2

(C) N_2 (D) HCl

(ii) Which of the following statements about dielectrics is correct ?

(A) A polar dielectric has a net dipole moment in absence of an external electric field which gets modified due to the induced dipoles.

(B) The net dipole moments of induced dipoles is along the direction of the applied electric field.

(C) Dielectrics contain free charges.

(D) The electric field produced due to induced surface charges inside a dielectric is along the external electric field.

(iii) When a dielectric slab is inserted between the plates of an isolated charged capacitor, the energy stored in it :

(A) increases and the electric field inside it also increases.

(B) decreases and the electric field also decreases.

(C) decreases and the electric field increases.

(D) increases and the electric field decreases.

(iv) (a) An air-filled capacitor with plate area A and plate separation d has capacitance C_0. A slab of dielectric constant K, area A and thickness $\left(\frac{d}{5}\right)$ is inserted between the plates. The capacitance of the capacitor will become

(A) $\left[\frac{4K}{5K+1}\right]C_0$ (B) $\left[\frac{K+5}{4}\right]C_0$

(C) $\left[\frac{5K}{4K+1}\right]C_0$ (D) $\left[\frac{K+4}{5K}\right]C_0$

OR

(iv) (b) Two capacitors of capacitances 2 C_0 and 6 C_0 are first connected in series and then in parallel across the same battery. The ratio of energies stored in series combination to that in parallel is

(A) $\frac{1}{4}$ (B) $\frac{1}{6}$

(C) $\frac{2}{15}$ (D) $\frac{3}{16}$

SECTION – E

31. (a) (i) You are given three circuit elements X, Y and Z. They are connected one by one across a given ac source. It is found that V and I are in phase for element X. V leads I by $\left(\frac{\pi}{4}\right)$ for element Y while I leads V by $\left(\frac{\pi}{4}\right)$ for element Z. Identify elements X, Y and Z.

(ii) Establish the expression for impedance of circuit when elements X, Y and Z are connected in series to an ac source. Show the variation of current in the circuit with the frequency of the applied ac source.

(iii) In a series LCR circuit, obtain the conditions under which (i) impedance is minimum and (ii) wattless current flows in the circuit.

OR

31. (b) (i) Describe the construction and working of a transformer and hence obtain the relation for $\left(\frac{v_s}{v_p}\right)$ in terms of number of turns of primary and secondary.

(ii) Discuss four main causes of energy loss in a real transformer.

32. (a) (i) A plane light wave propagating from a rarer into a denser medium, is incident at an angle i on the surface separating two media. Using Huygen's principle, draw the refracted wave and hence verify Snell's law of refraction.

(ii) In a Young's double slit experiment, the slits are separated by 0.30 mm and the screen is kept 1.5 m away. The wavelength of light used is 600 nm. Calculate the distance between the central bright fringe and the 4^{th} dark fringe.

OR

32. (b) (i) Discuss briefly diffraction of light from a single slit and draw the shape of the diffraction pattern.

(ii) An object is placed between the pole and the focus of a concave mirror. Using mirror formula, prove mathematically that it produces a virtual and an enlarged image.

33. (a) (i) Draw equipotential surfaces for an electric dipole.

(ii) Two point charges q_1 and q_2 are located at $\vec{r}_1$ and $\vec{r}_2$ respectively in an external electric field $\vec{E}$. Obtain an expression for the potential energy of the system.

(iii) The dipole moment of a molecule is 10^{-30} Cm. It is placed in an electric field $\vec{E}$ of 10^5 V/m such that its axis is along the electric field. The direction of $\vec{E}$ is suddenly changed by 60° at an instant. Find the change in the potential energy of the dipole, at that instant.

OR

33. (b) (i) A thin spherical shell of radius R has a uniform surface charge density σ. Using Gauss' law, deduce an expression for electric field (i) outside and (ii) inside the shell.

(ii) Two long straight thin wires AB and CD have linear charge densities 10 μC/m and -20 μC/m, respectively. They are kept parallel to each other at a distance 1 m. Find magnitude and direction of the net electric field at a point midway between them.