

Series : RP4QS



SET~3

प्रश्न-पत्र कोड
Q.P. Code

55/4/3

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

- (I) कृपया जाँच कर लें कि इस प्रश्न-पत्र में मुद्रित पृष्ठ (I) 31 हैं।
- (II) प्रश्न-पत्र में दाहिने हाथ की ओर दिए गए प्रश्न-पत्र (II) कोड को परीक्षार्थी उत्तर-पुस्तिका के मुख-पृष्ठ पर लिखें।
- (III) कृपया जाँच कर लें कि इस प्रश्न-पत्र में 33 प्रश्न (III) हैं।
- (IV) कृपया प्रश्न का उत्तर लिखना शुरू करने से (IV) पहले, उत्तर-पुस्तिका में यथा स्थान पर प्रश्न का क्रमांक अवश्य लिखें।
- (V) इस प्रश्न-पत्र को पढ़ने के लिए 15 मिनट का समय (V) 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। []

NOTE

- Please check that this question paper contains 31 printed pages.
- 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.
- Please check that this question paper contains 33 questions.
- Please write down the Serial Number of the question in the answer-book at the given place before attempting it.
- 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 carefully and follow them :

- (i) This question paper contains **33** questions. **All** questions are **compulsory**.
- (ii) This question paper is divided into **five** sections – **Sections A, B, C, D and E**.
- (iii) In **Section A** – Questions no. **1 to 16** are Multiple Choice type questions. Each question carries **1** mark.
- (iv) In **Section B** – Questions no. **17 to 21** are Very Short Answer type questions. Each question carries **2** marks.
- (v) In **Section C** – Questions no. **22 to 28** are Short Answer type questions. Each question carries **3** marks.
- (vi) In **Section D** – Questions no. **29 and 30** are case study-based questions. Each question carries **4** marks.
- (vii) In **Section E** – Questions no. **31 to 33** are Long Answer type questions. Each question carries **5** marks.
- (viii) There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the Sections except Section A.
- (ix) Kindly note that there is a separate question paper for Visually Impaired candidates.
- (x) Use of calculators is **not** allowed.

You may use the following values of physical constants wherever necessary :

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

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

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

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

$$\epsilon_0 = 8.854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$$

$$\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$$

$$\text{Mass of electron (m}_e\text{)} = 9.1 \times 10^{-31} \text{ kg}$$

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

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

$$\text{Avogadro's number} = 6.023 \times 10^{23} \text{ per gram mole}$$

$$\text{Boltzmann constant} = 1.38 \times 10^{-23} \text{ JK}^{-1}$$



SECTION A

1. Radiation of wavelength 331 nm irradiates the following metals :

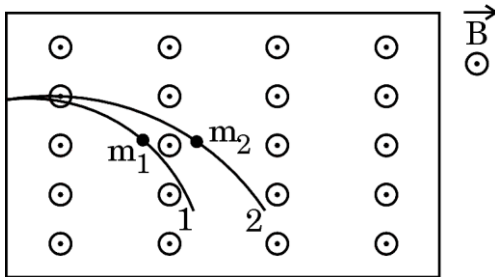
Metal	Work Function (eV)
Na	1.92
K	2.15
Ca	3.20
Mo	4.17

Which of the following statements is correct ?

- (A) Only Na and K show photoelectric emission.
 (B) Only Mo will not show photoelectric emission.
 (C) All of the given metals show photoelectric emission.
 (D) None of them show photoelectric emission.
2. The ratio of amplitude of electric field to the amplitude of the magnetic field associated with an electromagnetic wave propagating in glass ($n = 1.5$) is :
- (A) $3 \times 10^8 \text{ ms}^{-1}$ (B) $2 \times 10^8 \text{ ms}^{-1}$
 (C) $3.3 \times 10^{-9} \text{ ms}^{-1}$ (D) $5 \times 10^{-9} \text{ ms}^{-1}$
3. An ac voltage is given as $v = 14 \sin(314t) \text{ V}$. The average and the effective value of the voltage (in V) over a cycle are respectively :
- (A) 14 and 7 (B) 10 and 14
 (C) 0 and 10 (D) 10 and 0
4. In a reversed-biased p-n junction diode, the applied voltage mostly drops across :
- (A) p-region only
 (B) n-region only
 (C) depletion region
 (D) the diode



5. Two particles of masses m_1 and m_2 having charges q_1 and q_2 respectively are projected with the same velocity in a region of uniform magnetic field $\vec{B}$ pointing vertically upward. If they describe circular paths as shown in the figure, one may conclude that :



- (A) $\frac{m_1}{m_2} > \frac{q_1}{q_2}$ (B) $\frac{m_1}{m_2} > \frac{q_2}{q_1}$
- (C) $\frac{m_1}{m_2} < \frac{q_1}{q_2}$ (D) $\frac{m_1}{m_2} < \frac{q_2}{q_1}$
6. Paschen series in spectrum of hydrogen atom lies in :
- (A) infrared region
- (B) ultraviolet region
- (C) visible region
- (D) partly in ultraviolet region and partly in visible region
7. The kinetic energy of a charged particle is increased to four times of its initial value. The de Broglie wavelength associated with the particle will :
- (A) increase by 100% of its initial value.
- (B) increase by 50% of its initial value.
- (C) decrease by 25% of its initial value.
- (D) decrease by 50% of its initial value.



8. The resistivity ρ of a metal increases with rise in temperature because :
- (A) only relaxation time ' τ ' of electrons decreases with temperature.
 - (B) only number of electrons per unit volume ' n ' increases appreciably.
 - (C) ' τ ' decreases with temperature but ' n ' does not change appreciably.
 - (D) ' τ ' decreases with temperature and ' n ' increases.
9. Two coils are placed closed to each other. The mutual inductance of the pair of coils depends upon the :
- (A) rate at which currents change in the two coils.
 - (B) relative position and orientation of the coils.
 - (C) currents in the two coils.
 - (D) value of voltage induced in one coil due to change in value of current in the other coil.
10. Which of the following statements is true about mobility of charge carriers in a metal ?
- (A) Mobility increases with increase in applied electric field.
 - (B) Mobility decreases with increase in temperature.
 - (C) Mobility is independent of the mass of the charge carrier.
 - (D) Mobility increases with increase in temperature
11. A galvanometer of resistance G is converted into a voltmeter of range $(0 - V)$ by connecting a resistor of 250Ω with it. If resistor of 250Ω is replaced by another resistor of 900Ω , its range becomes $(0 - 3 V)$. The resistance G of the galvanometer is :
- (A) 150Ω
 - (B) 125Ω
 - (C) 100Ω
 - (D) 75Ω



12. Photons of frequency ν are incident on the surfaces of two metals A and B of threshold frequencies $\frac{\nu}{2}$ and $\frac{\nu}{3}$. The ratio of maximum kinetic energy of electrons emitted from metal A to that from metal B is :

- (A) $\frac{1}{3}$ (B) $\frac{3}{4}$
(C) $\frac{2}{3}$ (D) $\frac{3}{2}$

Questions number **13** to **16** 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) Both Assertion (A) and Reason (R) are false.
13. *Assertion (A)* : When a convex lens made of glass is immersed in water, its converging power increases.
Reason (R) : The focal length of a lens depends only on the radii of curvature of its two faces.
14. *Assertion (A)* : The conductivity of an n-type semiconductor is higher than that of a p-type semiconductor at a given temperature.
Reason (R) : The electrons being in the conduction band in n-type semiconductor are more mobile than the holes in the valence band in p-type semiconductor.



15. *Assertion (A)* : The work done, in taking a unit charge around a closed loop of an electric circuit involving cells and resistors in the loop, is zero.

Reason (R) : The potential at a point depends on the location of the point in the loop. After completing one round, the charge comes back to the point of start.

16. *Assertion (A)* : When a ferromagnetic substance is heated to high temperature it becomes paramagnetic in nature.

Reason (R) : The disappearance of magnetisation of a ferromagnet is abrupt and not gradual.

SECTION B

17. The hole concentration in an intrinsic semiconductor is $5 \times 10^8 \text{ m}^{-3}$. When it is doped with certain impurity, the electron concentration becomes $4 \times 10^{12} \text{ m}^{-3}$. Find the new value of the hole concentration. Also identify the type of new semiconductor formed after doping. 2

18. An electric dipole consists of two point charges $+1 \mu\text{C}$ and $-1 \mu\text{C}$, held 10 cm apart. It is subjected to a uniform electric field of 100 N/C. Calculate the amount of work done in turning the dipole from its position of stable equilibrium to the position of unstable equilibrium, in the field. 2



19. (a) State Huygens principle. How did Huygens justify the absence of the backwave on a spherical wavefront ? 2

OR

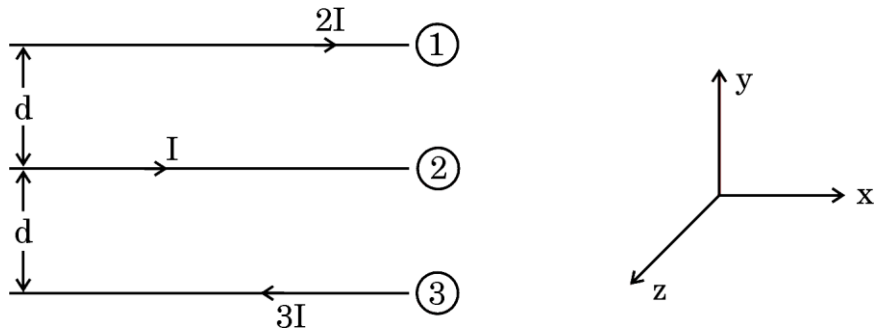
- (b) In a single-slit diffraction experiment, light of wavelength λ illuminates the slit of width 'a'. The diffraction pattern is observed on a screen kept at a distance D from the slits.
- (i) Depict variation of intensity in the fringe pattern with the angular position of the fringes.
- (ii) How is the linear width of central maximum affected when separation between the slit and the screen is decreased ? 2
20. A convex lens of refractive index 1.5 has a focal length of 20 cm in air. Find its nature and focal length when it is immersed in a transparent liquid of refractive index 1.25. 2
21. Differentiate between nuclear fission and nuclear fusion, giving one example for each. 2

SECTION C

22. With the help of a circuit diagram, explain the working of a full wave rectifier. Depict the input and output waveforms. 3
23. (a) Explain how the dual aspect of matter is evident in the de Broglie relation.
- (b) Radiation of wavelength λ is incident on a photosensitive surface. Find the de Broglie wavelength of electrons emitted from the surface. Assume that the work function of the surface is negligible. 3



24. (a) The figure given below shows three straight long parallel conductors (1), (2) and (3) kept in x-y plane, carrying currents $2I$, I and $3I$ respectively as shown in figure.



Find the magnitude and direction of :

- net magnetic field at a point on conductor (1) and
- net magnetic force acting on unit length of conductor (1), due to conductors (2) and (3).

3

OR

- A rectangular loop of sides l and b and resistance 'R' is kept in a region in which the magnetic field varies as $B = B_0 \sin \omega t$.
 - Derive expression for the emf induced in the loop.
 - Find the effective value of current that flows in the loop.

3

25. What are X-rays ? How are they produced ? Give two uses of X-rays.

3

- Distinguish between isotopes and isobars, giving one example for each.
- Derive the relation between atomic mass unit (u) and electron volt (eV).

3

- 'Current is a scalar quantity, although we represent current with an arrow.' Explain.
- Derive the balance condition of a Wheatstone Bridge.

3



28. Two coils, one of radius 0.5 cm having 10 turns and the other of radius 5 cm having 50 turns are placed coaxially in air such that their centres are coincident. Calculate :

- (a) the magnetic flux through the smaller coil if the larger coil carries a current of 3 A, and
- (b) the mutual inductance of the two coils.

3

SECTION D

Questions number 29 and 30 are Case Study-based questions. Read the following paragraphs and answer the questions that follow.

29. An astronomical telescope consists of two converging lenses. One of them of large aperture and large focal length is called objective lens and the other one, of smaller focal length and smaller aperture is called the eyepiece. It is used to see distant objects which are not seen clearly with naked eyes. The image formed by the objective lens acts as an object for the eyepiece and the final image produced by the eyepiece is magnified.

- (i) The images formed by the objective lens and the eyepiece are respectively :

1

- (A) virtual, real
- (B) real, virtual
- (C) virtual, virtual
- (D) real, real

- (ii) The magnification produced by the telescope does **not** depend upon the :

1

- (A) colour of light
- (B) focal length of objective lens
- (C) focal length of eyepiece
- (D) apertures of objective lens and eyepiece

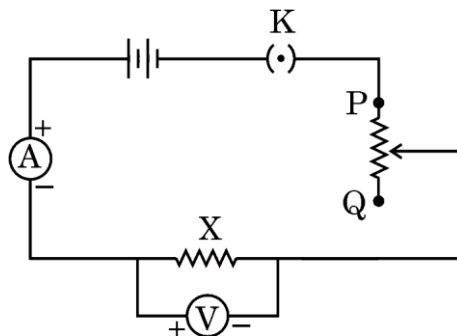


- (iii) Which of the following statements is **not** correct for this telescope ? 1
- (A) The focal length of objective lens (f_o) is larger than the focal length of eyepiece (f_e).
- (B) Its magnifying power can be increased by increasing the focal length of objective lens (f_o).
- (C) The distance between two lenses is more than ($f_o + f_e$).
- (D) The magnifying power can be decreased by increasing the focal length of eyepiece.
- (iv) (a) An astronomical telescope has objective lens and eyepiece of focal lengths 80 cm and 4 cm respectively. To view the image in normal adjustment, the lenses must be separated by a distance of : 1
- (A) 84 cm (B) 76 cm
- (C) 20 cm (D) 320 cm

OR

- (b) Consider the telescope described in question (iv) (a). Its magnifying power in normal adjustment will be : 1
- (A) 320 (B) 84
- (C) 76 (D) 20

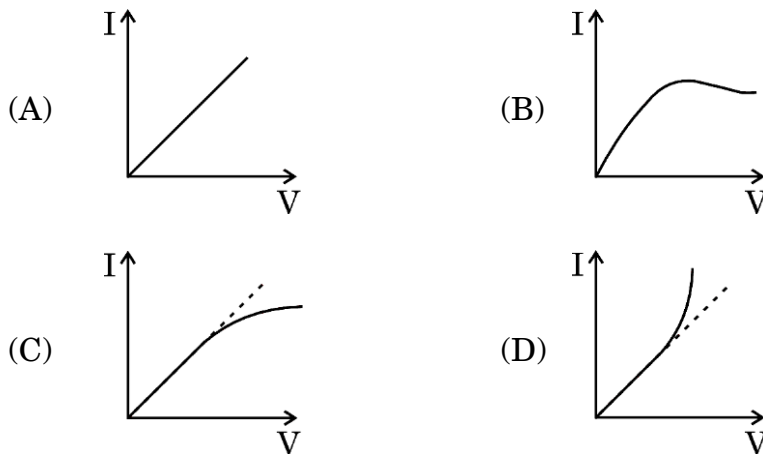
30. A student sets up the circuit as shown in the figure to find the value of unknown resistance X and records a set of readings of the voltmeter and the ammeter by using the rheostat.





- (i) If resistor X were made of manganin and readings for V and I are taken without switching off the circuit, the graph between V and I will be as :

1



- (ii) Error in the value of X obtained from different sets of voltmeter and ammeter readings, is :

1

- (A) due to error in voltmeter reading only.
- (B) due to error in ammeter reading only.
- (C) equal to the sum of error in voltmeter reading and error in ammeter reading.
- (D) equal to error in voltmeter reading divided by the error in ammeter reading.

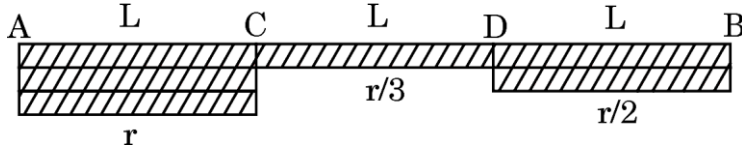
- (iii) If the movable end of rheostat is moved towards P, then :

1

- (A) reading in ammeter decreases and reading in voltmeter increases.
- (B) readings in both voltmeter and ammeter increase.
- (C) reading in ammeter increases and reading in voltmeter decreases.
- (D) readings in both voltmeter and ammeter decrease.



- (iv) (a) Suppose the unknown resistance X is replaced by a wire made of the same metal. This wire consists of three parts, of the same length L but has radii r , $r/3$ and $r/2$ as shown in the figure.



For a particular setting of the rheostat, let v_1 , v_2 and v_3 be the value of drift velocities in parts AC, CD and DB. Then : 1

- (A) $v_1 > v_2 > v_3$
 (B) $v_2 > v_3 > v_1$
 (C) $v_3 > v_2 > v_1$
 (D) $v_1 = v_2 = v_3$

OR

- (b) Consider the same wire, as shown in figure in question (iv) (a) connected in place of X. For a particular setting of rheostat, let E_1 , E_2 and E_3 be the value of electric fields in part AC, CD and DB. Then : 1

- (A) $E_1 = E_2 = E_3$
 (B) $E_3 > E_2 > E_1$
 (C) $E_2 > E_3 > E_1$
 (D) $E_1 > E_2 > E_3$



SECTION E

31. (a) (i) Define the terms (I) resonant frequency, and (II) power factor of a series LCR circuit. For what value of the power factor will the power dissipated in the circuit be maximum ?
- (ii) An inductor of $\frac{5}{\pi}$ H, a capacitor of $\frac{50}{\pi}$ μ F and a resistor of 400 Ω are connected in series across an ac voltage $v = 140 \sin (100\pi t)$ V. Calculate :
- (I) impedance of the circuit, and
- (II) rms value of current that flows in the circuit.
- (Take $\sqrt{2} = 1.4$)

5

OR

- (b) (i) Draw a labelled diagram of a step-up transformer. Obtain the ratio of secondary voltage to primary voltage in terms of number of turns in the two coils.
- (ii) The number of turns in the primary and the secondary coil of an ideal transformer are 100 and 5000 respectively. If 3.3 kW power is supplied to the transformer at 220 V, find (I) current in the primary coil, and (II) output voltage.

5

32. (a) (i) Explain the following statements giving reason :
- (I) An equipotential surface through a point is normal to the electric field at that point.
- (II) When a dielectric is placed in an external electric field, the electric field inside the dielectric is less than that outside it.
- (III) The potential difference between the plates of a charged parallel plate capacitor decreases when its plates are brought closer.



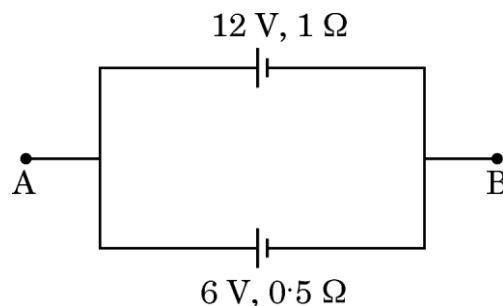
- (ii) Obtain an expression for the work done to dissociate the system of three charges q , $-4q$ and $2q$ placed at the vertices A, B and C respectively of an equilateral triangle of side 'a'. 5

OR

- (b) (i) Answer the following giving reason :

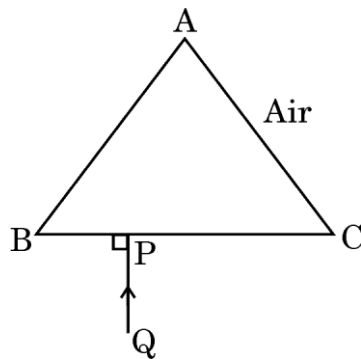
- (I) The electron drift speed is estimated to be only a few mm/s for currents in the range of a few amperes. How, then, is the current established almost the instant a circuit is closed ?
- (II) A low voltage supply from which one needs high currents must have very low internal resistance. Why ?
- (III) The assertion that $V = IR$ is a statement of Ohm's law is not true. Why ?

- (ii) Two cells of emfs 12 V and 6 V are connected in parallel as shown in the figure. Their internal resistances are $1\ \Omega$ and $0.5\ \Omega$ respectively. Calculate the emf and internal resistance of the equivalent cell between points A and B. 5





33. (a) (i) Define refractive index of a medium in terms of speed of light.
- (ii) Derive the relation for the refractive index (μ) of a prism in terms of angle of minimum deviation (δ_m) and angle of prism (A).
- (iii) A ray of light QP is incident normally on the face BC of a triangular prism ABC of refractive index 1.5 kept in air, as shown in the figure. Trace the path of the ray as it passes through the prism and give relevant explanation. 5



OR

- (b) (i) What is the difference between a ray and a wavefront ?
- (ii) A plane wave is incident on a reflecting surface. Using Huygens principle, show how it is reflected from the surface. Hence, verify the law of reflection.
- (iii) Depict refraction of a plane wave by a convex lens. 5