Series : 6ZXWY/6

SET ~ 3

रोल नं.
Roll No.

प्रश्न-पत्र कोड
Q.P. Code **55/6/3**

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)

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 **31** हैं। Please check that this question paper contains **31** 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 **33** प्रश्न हैं। Please check that this question paper contains **33** questions.
(IV)	**कृपया प्रश्न का उत्तर लिखना शुरू करने से पहले, उत्तर-पुस्तिका में यथा स्थान पर प्रश्न का क्रमांक अवश्य लिखें।** **Please write down the Serial Number of the question in the answer-book at the given place 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। 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 :

$c = 3 \times 10^8$ 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

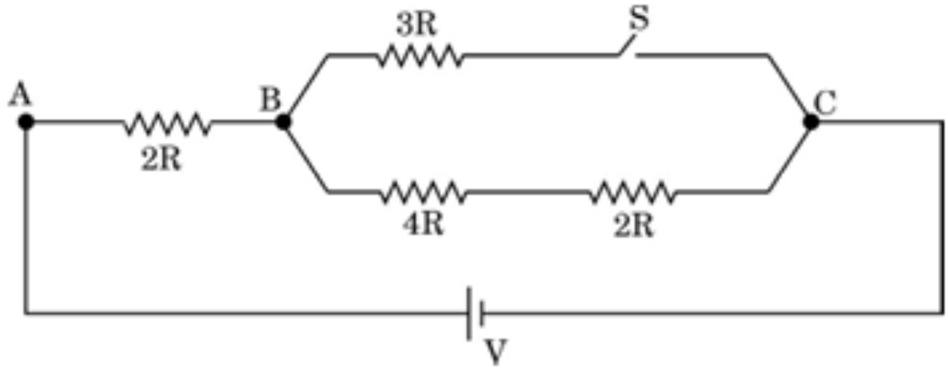
Mass of proton = $1{\cdot}673 \times 10^{-27}$ kg

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. The ratio of potential difference across AB in the circuit shown for the case (i) when switch S is closed and (ii) when S is open is :



(A) $\frac{1}{4}$ (B) $\frac{1}{2}$

(C) 1 (D) 2

2. Two coherent waves, each of intensity I_0, produce interference pattern on a screen. The average intensity of light on the screen is :

(A) zero (B) I_0

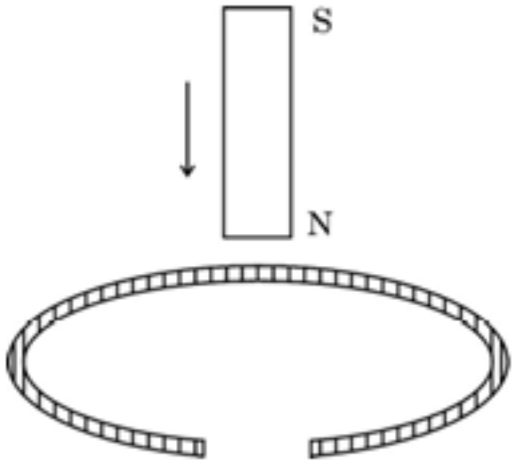
(C) $2I_0$ (D) $4I_0$

3. A particle of mass m and charge q moving with velocity $v\hat{i}$ is subjected to a uniform electric field $E\hat{j}$. The particle will initially have a tendency to move in a circle of radius :

(A) $\left(\frac{mv}{qE}\right)$ in x-y plane (B) $\left(\frac{mv^2}{qE^2}\right)$ in x-z plane

(C) $\left(\frac{mv^2}{qE}\right)$ in x-y plane (D) $\left(\frac{mv}{qE^2}\right)$ in y-z plane

4. A vertically held bar magnet is dropped along the axis of a copper ring having a cut as shown in the diagram. The acceleration of the falling magnet is :



(A) zero
(B) less than g
(C) g
(D) greater than g

5. Inside a nucleus, the nuclear forces between proton and proton, proton and neutron, neutron and neutron are F_{pp}, F_{pn} and F_{nn} respectively. Then :

(A) $F_{pp} > F_{pn} > F_{nn}$

(B) $F_{pn} > F_{nn} > F_{pp}$

(C) $F_{nn} > F_{pp} > F_{pn}$

(D) $F_{pp} = F_{pn} = F_{nn}$

6. An ac source is connected to a resistor and an inductor in series. The voltage across the resistor and inductor are 8 V and 6 V respectively. The voltage of the source is :

(A) 10 V
(B) 12 V
(C) 14 V
(D) 16 V

7. A proton and an α-particle enter with the same velocity $\vec{v}$ in a uniform magnetic field $\vec{B}$ such that $\vec{v} \perp \vec{B}$. The ratio of the radii of their paths is :

(A) 2 (B) $\frac{1}{2}$

(C) $\frac{1}{4}$ (D) 4

8. If R_s and R_p are the equivalent resistances of n resistors, each of value R, in series and parallel combinations respectively, then the value of $(R_s - R_p)$ is :

(A) $\left(\frac{n^2-1}{n^2}\right)R$ (B) $\left(\frac{n^2+1}{n^2-1}\right)R$

(C) $\left(\frac{n^2-1}{n}\right)R$ (D) $\frac{(n^2+1)R}{n^2}$

9. A piece of a diamagnetic material, free to move when placed in a uniform magnetic field :

(A) moves along the field

(B) moves opposite to the field

(C) moves perpendicular to the field

(D) does not move at all

10. The wavelength of a photon is equal to the wavelength associated with an electron. Both will have the same value of : *1*

(A) energy (B) angular momentum

(C) velocity (D) linear momentum

11. A galvanometer can be converted into an ammeter of desired range by connecting a :

(A) small resistance in series
(B) large resistance in series
(C) small resistance in parallel
(D) large resistance in parallel

12. The momentum (in kg m/s) of a photon of frequency $6 \cdot 0 \times 10^{14}$ Hz is :

(A) $6 \cdot 63 \times 10^{-25}$

(B) $1 \cdot 326 \times 10^{-27}$

(C) $2 \cdot 652 \times 10^{-26}$

(D) $3 \cdot 978 \times 10^{-24}$

*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) :* X-rays are produced when slow moving electrons are stopped by a metal target of high atomic number.

Reason (R) : X-rays consist of low-energy photons.

14. *Assertion (A) :* The binding energy per nucleon is practically constant for mass number in the range (30 < A < 170).

Reason (R) : Nuclear forces between the nucleons for mass numbers in the range (30 < A < 170) are not short-range.

15. *Assertion (A) :* In a reflecting telescope, the image does not have chromatic aberration.

Reason (R) : Chromatic aberration occurs only due to refraction of light through an optical medium.

16. *Assertion (A) :* A hole is an apparent free particle with effective positive electronic charge.

Reason (R) : A hole is not necessarily a vacancy left behind by an electron in the valence band.

SECTION B

17. In an n-type semiconductor electron-hole combination is a continuous process at room temperature. Yet the electron concentration is always greater than the hole concentration in it. Explain. *2*

18. (a) What is the difference between 'velocity' and 'drift velocity' of electrons in a current-carrying conductor.

(b) A copper wire of uniform cross-sectional area carries a current of 3·4 A. The drift velocity of conduction electrons is 0·2 mm/s. If the number density of electrons in copper is $8{\cdot}5 \times 10^{28}\ m^{-3}$, find the area of cross-section of the wire. *2*

19. (a) Find the intensity at a point on the screen in Young's double slit experiment, at which the interfering waves of intensity I_0 each, have a path difference of (i) $\frac{\lambda}{3}$, and (ii) $\frac{\lambda}{2}$. *2*

OR

(b) A point source of light in air is kept at a distance of 12 cm in front of a convex spherical surface of glass of refractive index 1·5 and radius of curvature 30 cm. Find the nature and position of the image formed. *2*

20. An alpha particle and a deuterium ion are accelerated through the same potential difference. These are then directed towards a target nucleus to make head-on collision. It is observed that their distance of closest approach is the same. Justify it theoretically. *2*

21. A tank is filled with a liquid of refractive index $\sqrt{2}$, up to a height of 30 cm. A tiny bulb is glowing at the bottom of the tank. Calculate the diameter of an opaque disc floating symmetrically on the liquid surface that can cut off completely the light from the bulb that comes out of the liquid surface. *2*

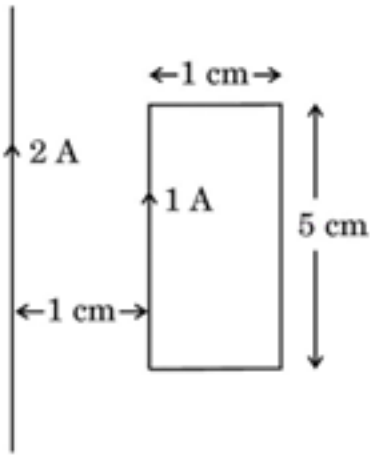
SECTION C

22. Name the electromagnetic wave used (i) in radar, (ii) in eye surgery and (iii) as diagnostic tool in medicine. Write their wavelength range also. *3*

23. (a) Differentiate between 'nuclear fission' and 'nuclear fusion'. Briefly discuss one example of each.

(b) Draw a graph of potential energy between a pair of nucleons as a function of their separation. *3*

24. A rectangular loop carries a current of 1 A. A straight long wire carrying 2 A current is kept near the loop in the same plane as shown in the figure.



Find : *3*

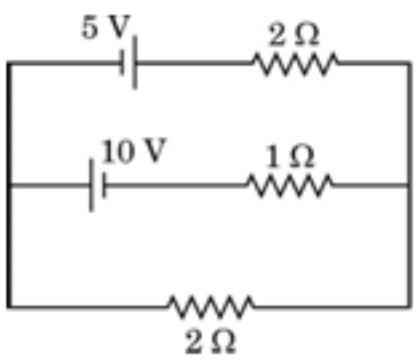
(i) the torque acting on the loop, and

(ii) the magnitude and direction of the net force on the loop.

25. (a) A concave mirror has radius of curvature 20 cm. Calculate the distance of an object from the mirror so as to form an image of magnification – 2. Also find the location of the image.

(b) If the silver coating around the centre of a concave mirror is removed, will the mirror still form the image of an object ? Justify your answer. *3*

26. State Kirchhoff's laws. Apply these laws to find the values of current flowing in the three branches of the given circuit. *3*



27. In Bohr model of hydrogen atom, an electron is revolving in second orbit. Find the value of :
    (i) angular momentum of electron,
    (ii) radius of the orbit, and
    (iii) kinetic energy of electron.

    Take radius of first orbit of hydrogen atom as 0·5 Å. *3*

28. (a) **State Lenz's law. A rod MN of length L is rotated about an axis** passing through its end M perpendicular to its length, with a constant angular velocity ω in a uniform magnetic field $\vec{B}$ parallel to the axis. Obtain an expression for emf induced between its ends. *3*

OR

(b) **Define 'self-inductance' of a coil. Derive an expression for** self-inductance of a long solenoid of cross-sectional area A and length l, having n turns per unit length. *3*

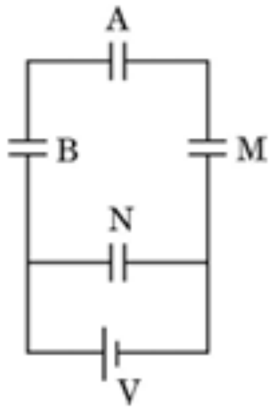
SECTION D

*Questions number **29** and **30** are case study-based questions. Read the following paragraphs and answer the questions that follow.*

29. A capacitor is a system of two conductors separated by an insulator. In practice, the two conductors have charges Q and – Q with potential difference $V = V_1 - V_2$ between them. The ratio $\frac{Q}{V}$ is a constant, denoted by C and is called the capacitance of the capacitor. It is independent of Q or V. It depends only on the geometrical configuration (shape, size, separation) of the two conductors and the medium separating the conductors. When a parallel plate capacitor is charged, the electric field E_0 is localised between the plates and is uniform throughout. When a slab of a dielectric is inserted between the charged plates (charge density σ), the dielectric is polarised by the field. Consequently opposite charges appear on the faces of the slab, near the plates, with surface charge density of magnitude σ_p. For a linear dielectric σ_p is proportional to E_0. Introduction of a dielectric changes the electric field, and hence, the capacitance of a capacitor, and hence, the energy stored in the capacitor.

Like resistors, capacitors can also be arranged in series or in parallel or in a combination of series and parallel.

(i) (a) Three capacitors A, B and M, each of capacitance C are connected to a capacitor N of capacitance 2C and a battery as shown in the figure. If the charges on A and N are Q and Q′ respectively, then $\frac{Q'}{Q}$ is : *1*



(A) $\frac{1}{6}$ (B) $\frac{1}{3}$

(C) 3 (D) 6

OR

(b) A slab (area A and thickness $\frac{d}{2}$) of dielectric constant K is inserted in a parallel plate capacitor of plate area A and plate separation d. If C and C_0 are the capacitances of the capacitors with and without the dielectric, then $\frac{C}{C_0}$ is : *1*

(A) $\frac{K+1}{2K}$ (B) $\frac{2K}{K+1}$

(C) $\frac{K}{K-1}$ (D) $\frac{K-1}{K}$

(ii) An electric field E is established between the plates of an air filled parallel plate capacitor, with charges Q and – Q. V is the volume of the space enclosed between the plates. The energy stored in the capacitor is : *1*

(A) $\frac{1}{2}\varepsilon_0 E^2$ (B) $\varepsilon_0 Q^2 E$

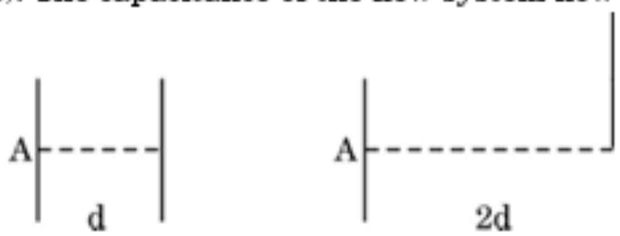
(C) $\frac{1}{2}\varepsilon_0 E^2 V$ (D) $\varepsilon_0 E Q V$

(iii) A slab (area A and thickness d_1) of a linear dielectric of dielectric constant K is inserted between charged plates (charge density σ) of a parallel plate capacitor [plate area A and plate separation d (> d_1)] and opposite charges with charge density of magnitude σ_p appear on the faces of the slab. The dielectric constant K is given by : *1*

(A) $\frac{\sigma + \sigma_p}{\sigma}$ (B) $\frac{\sigma}{\sigma - \sigma_p}$

(C) $\frac{\sigma + \sigma_p}{\sigma_p}$ (D) $\frac{\sigma}{\sigma_p}$

(iv) Consider a capacitor of capacitance C, with plate area A and plate separation d, filled with air [Fig. (a)]. The distance between the plates is increased to 2d and one of the plates is shifted as shown in Fig. (b). The capacitance of the new system now is : *1*



(a) (b)

(A) $\frac{C}{4}$ (B) $\frac{C}{2}$

(C) 2C (D) 4C

30. Extrinsic semiconductors are made by doping pure or intrinsic semiconductors with suitable impurity. There are two type of dopants used in doping, Si or Ge, and using them p-type and n-type semiconductors can be obtained. A p-n junction is the basic building block of many semiconductor devices. Two important processes occur during the formation of a p-n junction : diffusion and drift. When such a junction is formed, a 'depletion layer' is created consisting of immobile ion-cores. This is responsible for a junction potential barrier. The width of a depletion layer and the height of potential barrier changes when a junction is forward-biased or reverse-biased. A semiconductor diode is basically a p-n junction with metallic contacts provided at the ends for application of an external voltage. Using diodes, alternating voltages can be rectified.

(i) (a) In reverse-biased p-n junction : *1*

(A) the drift current is of the order of few mA.

(B) the applied voltage mostly drops across the depletion region.

(C) the depletion region width decreases.

(D) the current increases with increase in applied voltage.

OR

(b) The output frequency of a full-wave rectifier with 50 Hz as input frequency is : *1*

(A) 25 Hz (B) 50 Hz

(C) 100 Hz (D) 200 Hz

(ii) During formation of a p-n junction : *1*

(A) a layer of negative charge on n-side and a layer of positive charge on p-side appear.

(B) a layer of positive charge on n-side and a layer of negative charge on p-side appear.

(C) the electrons on p-side of the junction move to n-side initially.

(D) initially diffusion current is small and drift current is large.

(iii) When a pentavalent atom occupies the position of an atom in the crystal lattice of Si, four of its electrons form covalent bonds with four silicon neighbours, while the fifth remains bound to the parent atom. The energy required to set this electron free is about : *1*

(A) 0·5 eV (B) 0·1 eV

(C) 0·05 eV (D) 0·01 eV

(iv) Which of the following is a donor impurity atom for Ge ? *1*

(A) Boron (B) Antimony

(C) Aluminium (D) Indium

SECTION E

31. (a) (i) The electric field in a region is given by $\vec{E} = 40x\ \hat{i}$ N/C. Find the amount of work done in taking a unit positive charge from a point (0, 3m) to the point (5m, 0).

(ii) A charge Q is distributed over two concentric hollow spheres of radii r and R (> r) such that their surface charge densities are equal. Find :

(I) the electric field, and

(II) the potential

at their common centre. *5*

OR

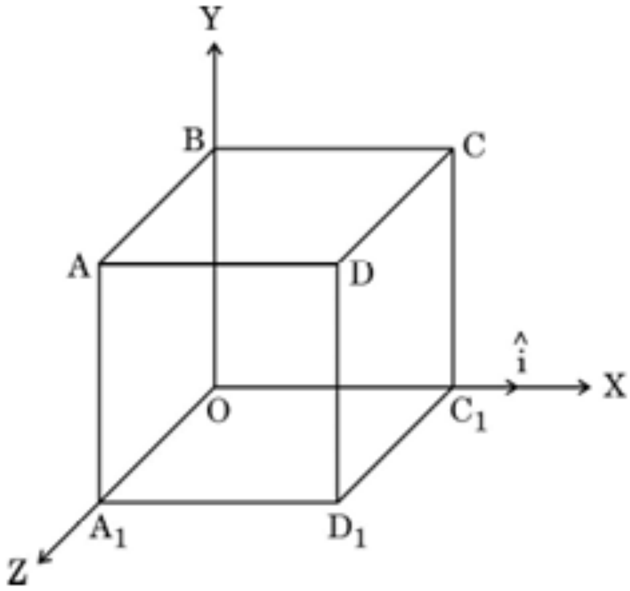
(b) (i) Obtain an expression for the electric field $\vec{E}$ due to a dipole of dipole moment $\vec{p}$ at a point on its equatorial plane and specify its direction. Hence, find the value of electric field :

(I) at the centre of the dipole (r = 0), and

(II) at a point r >> a,

where 2a is the length of the dipole.

(ii) An electric field $\vec{E} = (10x + 5)\hat{i}$ N/C exists in a region in which a cube of side L is kept as shown in the figure. Here x and L are in metres. Calculate the net flux through the cube. *5*



32. (a) (i) Write the principle of working of an ac generator. Draw its labelled diagram and explain its working.

(ii) A resistor of 400 Ω, an inductor of $\left(\frac{5}{\pi}\right)$H and a capacitor of $\left(\frac{50}{\pi}\right)\mu$F are joined in series across an ac source $v = 140 \sin(100\pi)t$ V. Find the rms voltages across these three circuit elements. The algebraic sum of these voltages is more than the rms voltage of source. Explain. *5*

OR

(b) (i) Write the principle of working of a transformer. With the help of a labelled diagram, explain the working of a step-up transformer.

(ii) An ideal transformer is designed to convert 50 V into 250 V. It draws 200 W power from an ac source whose instantaneous voltage is given by $v_i = 20 \sin (100\pi)t$ V.

Find :

(I) rms value of input current.

(II) expression for instantaneous output voltage.

(III) expression for instantaneous output current. *5*

33. (a) (i) Draw a ray diagram to show the image formation by a compound microscope. Obtain the expression for the total magnification of the microscope when the final image is formed at infinity.

(ii) In a compound microscope, an object is placed at a distance of 1·5 cm from the objective of focal length 1·25 cm. The eyepiece has a focal length of 5 cm. The final image is formed at infinity. Calculate the distance between the objective and the eyepiece. *5*

OR

(b) (i) Using Huygens' principle, explain the refraction of a plane wavefront, propagating in air, at a plane interface between air and glass. Hence verify Snell's law.

(ii) Use mirror formula to deduce that a convex mirror always produces a virtual image of an object kept in front of it. *5*