Series : YWX5Z/5

SET ~ 3

रोल नं.
Roll No.

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)

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 **27** हैं। Please check that this question paper contains **27** 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. A beam of light of wavelength 720 nm in air enters water (refractive index = $\frac{4}{3}$). Its wavelength in water will be :

(A) 540 nm (B) 480 nm
(C) 420 nm (D) 720 nm

2. A capacitor of capacitance C has reactance X in an ac circuit. If the capacitance and the frequency of the applied voltage are doubled, the new reactance will become :

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

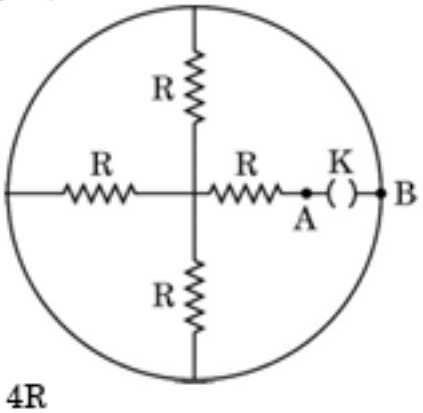
3. Four point charges Q each, are held at the four corners of a square of side l. The amount of work done in bringing a charge Q from infinity to the centre of the square will be :

(A) $\frac{Q^2}{\pi \varepsilon_0 l}$ (B) $\frac{\sqrt{2}Q^2}{\pi \varepsilon_0 l}$
(C) $\frac{Q^2}{2\pi \varepsilon_0 l}$ (D) Zero

4. A metal sheet is inserted between the plates of a parallel plate capacitor of capacitance C. If the sheet partly occupies the space between the plates, the capacitance :

(A) remains C (B) becomes greater than C
(C) becomes less than C (D) becomes zero

5. Four resistors, each of resistance R and a key K are connected as shown in the figure. The equivalent resistance between points A and B when key K is open, will be :



(A) 4R (B) ∞
(C) $\frac{R}{4}$ (D) $\frac{4R}{3}$

#

6. A charged particle gains a speed of 10^6 ms^{-1}, when accelerated from rest through a potential difference 10 kV. It enters a region of magnetic field of 0·4 T such that $\vec{v} \perp \vec{B}$. The radius of circular path described by it is :

(A) 2·5 cm (B) 5 cm

(C) 8 cm (D) 10 cm

7. A current of $\left(\frac{10}{\pi}\right)$A is maintained in a circular loop of radius 14 cm. The value of dipole moment associated with the loop is :

(A) 0·019 Am^2 (B) 0·14 Am^2

(C) 0·196 Am^2 (D) 0·615 Am^2

8. Which of the following rays coming from the Sun plays an important role in maintaining the Earth's warmth ?

(A) Infrared rays (B) γ rays

(C) UV rays (D) Visible light rays

9. The dimensions of $(\mu\varepsilon)^{-1}$, where ε is permittivity and μ is permeability of a medium, are :

(A) $[M^0 L^1 T^{-1}]$ (B) $[M^0 L^2 T^{-2}]$

(C) $[M^1 L^2 T^{-2}]$ (D) $[M^1 L^{-1} T^1]$

10. Which of the following electromagnetic waves has photons of largest momentum ?

(A) X-rays (B) AM radio waves

(C) Microwaves (D) TV waves

11. The kinetic energy of an alpha particle is four times the kinetic energy of a proton. The ratio $\left(\frac{\lambda_\alpha}{\lambda_p}\right)$ of de Broglie wavelengths associated with them will be :

(A) $\frac{1}{16}$ (B) $\frac{1}{8}$

(C) $\frac{1}{4}$ (D) $\frac{1}{2}$

#

12. Two coherent light waves, each having amplitude 'a', superpose to produce an interference pattern on a screen. The intensity of light as seen on the screen varies between :

(A) 0 and $2a^2$ (B) 0 and $4a^2$

(C) a^2 and $2a^2$ (D) $2a^2$ and $4a^2$

*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) :* During formation of a nucleus, the mass defect produced is the source of the binding energy of the nucleus.

Reason (R) : For all nuclei, the value of binding energy per nucleon increases with mass number.

14. *Assertion (A) :* In Rutherford's alpha particle scattering experiment, the presence of only few alpha particles at angle of scattering π led him to the discovery of nucleus.

Reason (R) : The size of nucleus is approximately 10^{-5} times the size of an atom and therefore only few alpha particles are rebounded.

15. *Assertion (A) :* The impurities in p-type Si are not pentavalent atoms.

Reason (R) : The hole density in valance band in p-type semiconductor is almost equal to the acceptor density.

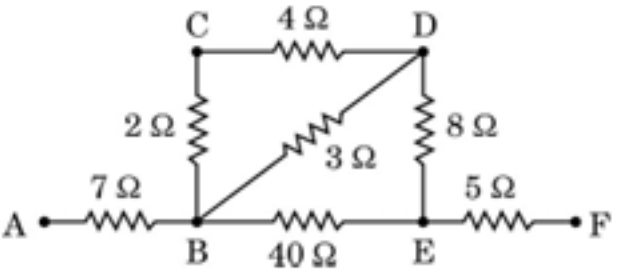
#

16. *Assertion (A) :* The Balmer series in hydrogen atom spectrum is formed when the electron jumps from higher energy state to the ground state.

Reason (R) : In Bohr's model of hydrogen atom, the electron can jump between successive orbits only.

SECTION B

17. Find the effective resistance of the network of resistors between points A and F as shown in the figure. *2*



18. A current of 5 A is passing along +X direction through a wire lying along X-axis. Find the magnetic field $\vec{B}$ at a point $\vec{r} = (3\hat{i} + 4\hat{j})$ m due to 1 cm element of the wire, centered at origin. *2*

19. Define the term, 'distance of closest approach'. A proton of 3·95 MeV energy approaches a target nucleus Z = 79 in head-on position. Calculate its distance of closest approach. *2*

20. (a) A point object is placed in air at a distance R/3 in front of a convex surface of radius of curvature R, separating air from a medium of refractive index n (< 4). Find the nature and position of the image formed. *2*

OR

(b) In Young's double slit experimental set-up, the intensity of the central maximum is I_0. Calculate the intensity at a point where the path difference between two interfering waves is $\lambda/3$. *2*

21. The threshold frequency for a given metal is $3{\cdot}6 \times 10^{14}$ Hz. If monochromatic radiations of frequency $6{\cdot}8 \times 10^{14}$ Hz are incident on this metal, find the cut-off potential for the photoelectrons. *2*

#

SECTION C

22. (a) **"There is a limit to the amount of charge that can be stored on a given capacitor." Explain.**

(b) A capacitor is charged by a battery to a potential difference V. It is disconnected from the battery and connected across another identical uncharged capacitor. Calculate the ratio of total energy stored in the combination to the initial energy stored in the capacitor. *3*

23. (a) **"You cannot see a person standing on the other side of a boundary wall but can hear him." Explain with reason.**

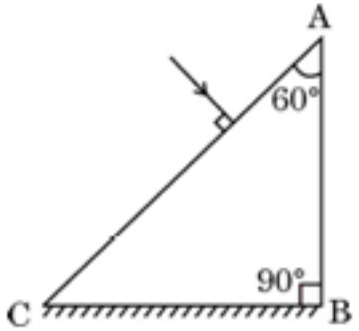
(b) Light of wavelength 750 nm is incident normally on a slit of width 1·5 mm. Diffraction pattern is obtained on a screen 1·0 m away from the slit. Find the distance of the nearest point from the central maxima at which the intensity is zero. *3*

24. The magnetic moment (5J/T) of a bar magnet points along a uniform magnetic field 0·4 T.

(a) Calculate (i) the potential energy of the bar magnet, and (ii) the work done in turning the magnet by 180°.

(b) In which case is the potential energy of the magnet minimum ? *3*

25. A right-angled prism ABC (refractive index $\sqrt{2}$) is kept on a plane mirror as shown in the figure. A ray of light is incident normally on the face AC.



(a) Trace the path of the ray as it passes through the prism.

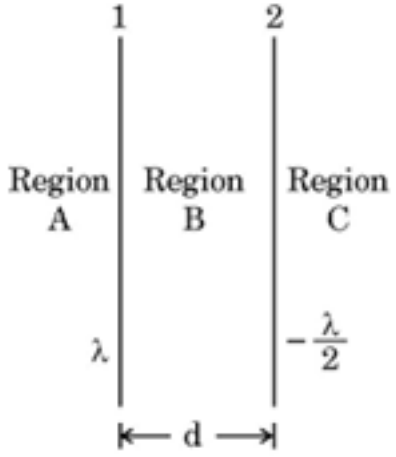
(b) Find the angle of deviation produced by the prism. *3*

#

26. (a) Two small solid metal balls A and B of radii R and 2R having charge densities 2σ and 3σ respectively are kept far apart. Find the charge densities on A and B after they are connected by a conducting wire. *3*

OR

(b) **Two infinitely long straight wires '1' and '2' are placed d distance apart, parallel to each other, as shown in the figure. They are uniformly charged having charge densities λ and $-\frac{\lambda}{2}$ respectively. Locate the position of the point from wire '1' at which the net electric field is zero and identify the region in which it lies.** *3*



27. (a) Draw the energy-band diagrams for conductors, semiconductors and insulators at T = 0 K. How is an electron-hole pair formed in a semiconductor at room temperature ?

(b) Carbon and silicon both, are members of IV group of periodic table and have the same lattice structure. Carbon is an insulator whereas silicon is a semiconductor. Explain. *3*

28. Differentiate between half-wave and full-wave rectification. With the help of a circuit diagram, explain the working of a full-wave rectifier. *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 galvanometer is an instrument used to show the direction and strength of the current passing through it. In a galvanometer, a coil placed in a magnetic field experiences a torque and hence gets deflected when a current passes through it. The name is derived from the surname of Italian scientist L. Galvani, who in 1791 discovered that electric current makes a dead frog's leg jerk. A spring attached with the coil provides a counter torque.

In equilibrium, the deflecting torque is balanced by the restoring torque of the spring and we have :

$$NBAI = k\phi$$

where N is the total number of turns in the coil

A is the area of cross-section of each turn

B is the radial magnetic field

k is the torsional constant of the spring

ϕ is the angular deflection of the coil

As the current (I_g) which produces full scale deflection in the galvanometer is very small, the galvanometer cannot as such be used to measure current in electric circuits. A small resistance, called shunt, of a suitable value is connected with the galvanometer to convert it into an ammeter of desired range. By using a higher resistance, a galvanometer can also be converted into a voltmeter.

(i) (a) A galvanometer is converted into a voltmeter of range (0 – V) by connecting with it, a resistance R_1. If R_1 is replaced by R_2, the range becomes (0 – 2 V). The resistance of the galvanometer is : *1*

(A) $(R_2 - 2R_1)$ (B) $(R_2 - R_1)$

(C) $(R_1 + R_2)$ (D) $(R_1 - 2R_2)$

OR

#

(b) A current of 5 mA flows through a galvanometer. Its coil has 100 turns, each of area of cross-section 18 cm^2 and is suspended in a magnetic field 0·20 T. The deflecting torque acting on the coil will be : *1*

(A) $3{\cdot}6 \times 10^{-3}$ Nm (B) $1{\cdot}8 \times 10^{-4}$ Nm

(C) $2{\cdot}4 \times 10^{-3}$ Nm (D) $1{\cdot}2 \times 10^{-4}$ Nm

(ii) The value of resistance of the ammeter in case (ii) will be : *1*

(A) 0·20 Ω (B) 0·24 Ω

(C) 6·0 Ω (D) 6·25 Ω

(iii) A galvanometer of resistance 6 Ω shows full scale deflection for a current of 0·2 A. The value of shunt to be used with this galvanometer to convert it into an ammeter of range (0 – 5 A) is : *1*

(A) 0·25 Ω (B) 0·30 Ω

(C) 0·50 Ω (D) 6·0 Ω

(iv) The value of the current sensitivity of a galvanometer is given by : *1*

(A) $\frac{k}{NBA}$ (B) $\frac{NBA}{k}$

(C) $\frac{kBA}{N}$ (D) $\frac{kNB}{A}$

30. Einstein explained photoelectric effect on the basis of Planck's quantum theory, where light travels in the form of small bundles of energy called photons. The energy of each photon is hν, where ν is the frequency of incident light and h is Planck's constant. The number of photons in a beam of light determines the intensity of the incident light. A photon incident on a metal surface transfers its total energy hν to a free electron in the metal. A part of this energy is used in ejecting the electron from the metal and is called its work function. The rest of the energy is carried by the ejected electron as its kinetic energy.

(i) Which of the following graphs can be used to obtain the value of Planck's constant ? *1*

(A) Photocurrent versus Intensity of incident light

(B) Photocurrent versus Frequency of incident light

(C) Cut-off potential versus Frequency of incident light

(D) Cut-off potential versus Intensity of incident light

#

(ii) (a) Red light, yellow light and blue light of the same intensity are incident on a metal surface successively. K_R, K_Y and K_B represent the maximum kinetic energy of photoelectrons respectively, then : *1*

(A) $K_R > K_Y > K_B$ (B) $K_Y > K_B > K_R$

(C) $K_B > K_Y > K_R$ (D) $K_R > K_B > K_Y$

OR

(b) Which of the following metals exhibits photoelectric effect with visible light ? *1*

(A) Caesium (B) Zinc

(C) Cadmium (D) Magnesium

(iii) When the frequency of the incident light is increased without changing its intensity, the saturation current : *1*

(A) increases linearly

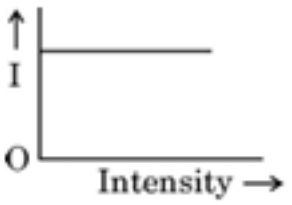
(B) decreases

(C) increases non-linearly

(D) remains the same

(iv) Which of the following graphs shows the variation of photoelectric current I with the intensity of light ? *1*

(A) 

(B) 

(C) 

(D) 

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SECTION E

31. (a) (i) Draw a ray diagram of a reflecting telescope (Cassegrain) and explain the formation of image. State two important advantages that a reflecting telescope has over a refracting telescope.

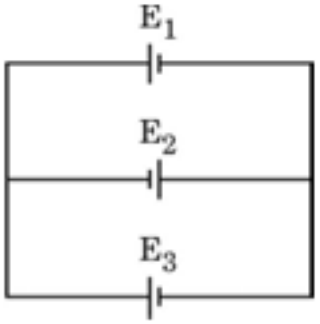
(ii) In a refracting telescope, the focal length of the objective is 50 times the focal length of the eyepiece. When the final image is formed at infinity, the length of the tube is 102 cm. Find the focal lengths of the two lenses. *5*

OR

(b) (i) Write any two advantages of a compound microscope over a simple microscope. Draw a ray diagram for the image formation at the near point by a compound microscope and explain it.

(ii) A thin planoconcave lens with its curved face of radius of curvature R is made of glass of refractive index n_1. It is placed coaxially in contact with a thin equiconvex lens of same radius of curvature of refractive index n_2. Obtain the power of the combination lens. *5*

32. (a) (i) Three batteries E_1, E_2 and E_3 of emfs and internal resistances (4 V, 2 Ω), (2 V, 4 Ω) and (6 V, 2 Ω) respectively are connected as shown in the figure. Find the values of the currents passing through batteries E_1, E_2 and E_3.



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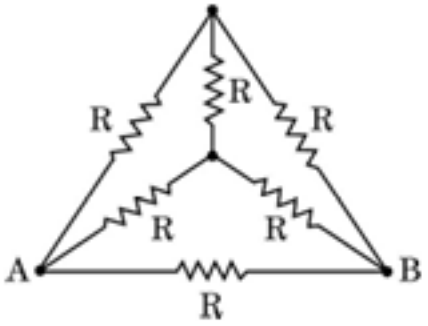
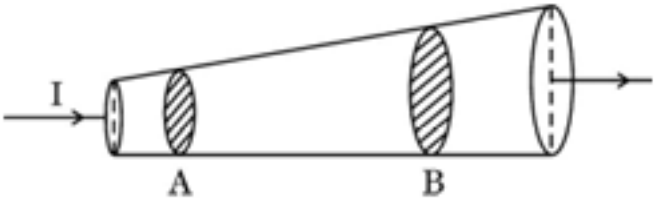
(ii) The ends of six wires, each of resistance R (= 10 Ω) are joined as shown in the figure. The points A and B of the arrangement are connected in a circuit. Find the value of the effective resistance offered by it to the circuit. *5*



OR

(b) (i) Current I (= 1 A) is passing through a copper rod ($n = 8{\cdot}5 \times 10^{28}\ m^{-3}$) of varying cross-sections as shown in the figure. The areas of cross-section at points A and B along its length are $1{\cdot}0 \times 10^{-7}\ m^2$ and $2{\cdot}0 \times 10^{-7}\ m^2$ respectively. Calculate :



(I) the ratio of electric fields at points A and B.

(II) the drift velocity of free electrons at point B.

(ii) Two point charges q_1 (= 16 μC) and q_2 (= 1 μC) are placed at points $\vec{r}_1 = (3\ m)\hat{i}$ and $\vec{r}_2 = (4\ m)\hat{j}$. Find the net electric field $\vec{E}$ at point $\vec{r} = (3\ m)\hat{i} + (4\ m)\hat{j}$. *5*

33. (a) (i) Define self-inductance of a coil. Derive the expression for the energy required to build up a current I in a coil of self-inductance L.

(ii) The currents passing through two inductors of self-inductances 10 mH and 20 mH increase with time at the same rate.

Draw graphs showing the variation of :

(I) the magnitude of emf induced with the rate of change of current in each inductor.

(II) the energy stored in each inductor with the current flowing through it. *5*

OR

(b) (i) Define the term mutual inductance. Deduce the expression for the mutual inductance of two long coaxial solenoids of the same length having different radii and different number of turns.

(ii) The current through an inductor is uniformly increased from zero to 2 A in 40 s. An emf of 5 mV is induced during this period. Find the flux linked with the inductor at t = 10 s. *5*