Series : YXZW2

SET ~ 2

रोल नं.
Roll No.

कोड नं.
Code No. 55/2/2

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 23 हैं ।
Please check that this question paper contains 23 printed pages.

(II) कृपया जाँच कर लें कि इस प्रश्न-पत्र में 33 प्रश्न हैं ।
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 ।
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 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 very 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*** *: Question numbers* ***1*** *to* ***16*** *are Multiple Choice type questions. Each question carries* ***1*** *mark.*

(iv) *In* ***Section B*** *: Question numbers* ***17*** *to* ***21*** *are Very Short Answer type questions. Each question carries* ***2*** *marks.*

(v) *In* ***Section C*** *: Question numbers* ***22*** *to* ***28*** *are Short Answer type questions. Each question carries* ***3*** *marks.*

(vi) *In* ***Section D*** *: Question numbers* ***29 & 30*** *are case study-based questions. Each question carries* ***4*** *marks.*

(vii) *In* ***Section E*** *: Question numbers* ***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

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

Boltzman's constant = 1.38×10^{-23} JK^{-1}

SECTION – A

1. Two identical point charges are placed at the two vertices A and B of an equilateral triangle of side *l*. The magnitude of the electric field at the third vertex P is E. If a hollow conducting sphere of radius (*l*/4) is placed at P, the magnitude of the electric field at point P now becomes 1

(A) >E (B) E

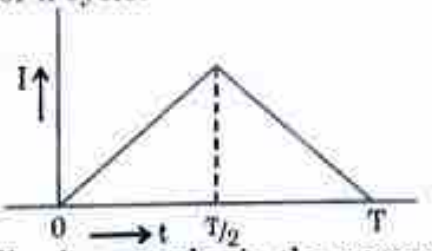
(C) $\frac{E}{2}$ (D) zero

2. A battery of e.m.f. 12 V and internal resistance 0.5 Ω is connected to a 9.5 Ω resistor through a key. The ratio of potential difference between the two terminals of the battery, when the key is open to that when the key is closed, is 1

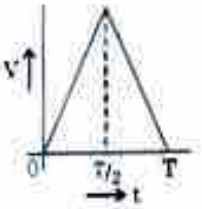
(A) 1.05 (B) 1

(C) 0.95 (D) 1.1

3. The alternating current I in an inductor is observed to vary with time t as shown in the graph for a cycle. 1



Which one of the following graphs is the correct representation of wave form of voltage V with time t ?

(A)


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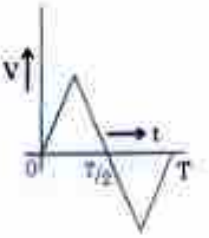
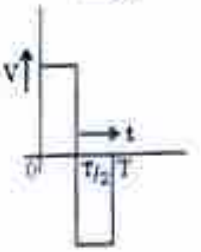
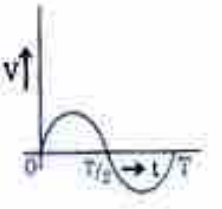


(C)


(D)


4. A diamagnetic substance is brought, one by one, near the north pole and the south pole of a bar magnet. It is 1

(A) repelled by north pole and attracted by south pole.

(B) attracted by north pole and repelled by south pole.

(C) attracted by north pole as well as by south pole.

(D) repelled by north pole as well as by south pole.

5. Two long solenoids of radii r_1 and r_2 ($>r_1$) and number of turns per unit length n_1 and n_2 respectively are co-axially wrapped one over the other. The ratio of self-inductance of inner solenoid to their mutual inductance is – 1

(A) $\frac{n_1}{n_2}$ (B) $\frac{n_2}{n_1}$

(C) $\frac{n_1 r_1^2}{n_2 r_2^2}$ (D) $\frac{n_2 r_1^2}{n_1 r_2^2}$

6. A 1 cm straight segment of a conductor carrying 1 A current in x direction lies symmetrically at origin of Cartesian coordinate system. The magnetic field due to this segment at point (1m, 1m, 0) is 1

(A) $1.0 \times 10^{-9}\,\hat{k}$ T (B) $-1.0 \times 10^{-9}\,\hat{k}$ T

(C) $\frac{5.0}{\sqrt{2}} \times 10^{-10}\,\hat{k}$ T (D) $-\frac{5.0}{\sqrt{2}} \times 10^{-10}\,\hat{k}$ T

7. A coil of an ac generator, having 100 turns and area 0.1 m^2 each, rotates at half a rotation per second in a magnetic field of 0.02 T. The maximum emf generated in the coil is 1

(A) 0.31 V (B) 0.20 V

(C) 0.63 V (D) 0.10 V

8. Atomic spectral emission lines of hydrogen atom are incident on a zinc surface. The lines which can emit photoelectrons from the surface are members of 1

(A) Balmer series
(B) Paschen series
(C) Lyman series
(D) Neither Balmer, nor Paschen nor Lyman series

9. The focal length of a concave mirror in air is f. When the mirror is immersed in a liquid of refractive index $\frac{5}{3}$, its focal length will become 1

(A) $\frac{5}{3}$f (B) $\frac{3}{5}$f

(C) $\frac{2}{3}$f (D) f

10. Which one of the following statements is correct ? 1

Electric field due to static charges is

(A) conservative and field lines do not form closed loops.
(B) conservative and field lines form closed loops.
(C) non-conservative and field lines do not form closed loops.
(D) non-conservative and field lines form closed loops.

11. When the resistance measured between p and n ends of a p-n junction diode is high, it can act as a/an – 1

(A) resistor (B) inductor

(C) capacitor (D) switch

12. The energy of an electron in a hydrogen atom in ground state is –13.6 eV. Its energy in an orbit corresponding to quantum number n is –0.544 eV. The value of n is 1

(A) 2 (B) 3

(C) 4 (D) 5

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 codes (A), (B), (C) and (D) as given below :

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

(B) If both Assertion (A) and Reason (R) are true but 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)** : Out of Infrared and radio waves, the radio waves show more diffraction effect. 1

Reason (R) : Radio waves have greater frequency than infrared waves.

14. **Assertion (A)** : In an ideal step-down transformer, the electrical energy is not lost. 1

Reason (R) : In a step-down transformer, voltage decreases but the current increases.

15. **Assertion (A)** : In Bohr model of hydrogen atom, the angular momentum of an electron in n^{th} orbit is proportional to the square root of its orbit radius r_n. 1

Reason (R) : According to Bohr model, electron can jump to its nearest orbits only.

16. **Assertion (A)** : In a semiconductor diode the thickness of depletion layer is not fixed. 1

Reason (R) : Thickness of depletion layer in a semiconductor device depends upon many factors such as biasing of the semiconductor.

SECTION – B

17. The threshold voltage of a silicon diode is 0.7 V. It is operated at this point by connecting the diode in series with a battery of V volt and a resistor of 1000 Ω. Find the value of V when the current drawn is 15 mA. 2

18. Show the refraction of light wave at a plane interface using Huygens' principle and prove Snell's law. 2

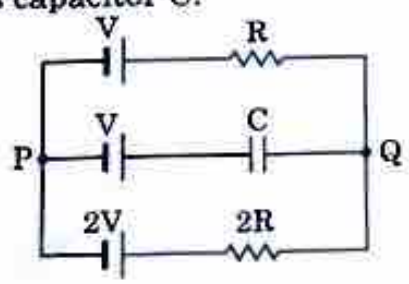
19. Two convex lenses A and B, each of focal length 10.0 cm, are mounted on an optical bench at 50.0 cm and 70.0 cm respectively. An object is mounted at 20.0 cm. Find the nature and position of the final image formed by the combination. 2

20. Radiations of two frequencies are incident on a metal surface of work function 2.0 eV one by one. The energies of their photons are 2.5 eV and 4.5 eV respectively. Find the ratio of the maximum speed of the electrons emitted in the two cases. 2

21. (a) Two wires of the same material and the same radius have their lengths in the ratio 2 : 3. They are connected in parallel to a battery which supplies a current of 15 A. Find the current through the wires. 2

OR

(b) In the circuit three ideal cells of e.m.f. V, V and 2V are connected to a resistor of resistance R, a capacitor of capacitance C and another resistor of resistance 2R as shown in figure. In the steady state find (i) the potential difference between P and Q and (ii) potential difference across capacitor C.



SECTION – C

22. (a) Define resistivity of a conductor. Discuss its dependence on temperature of the conductor and draw a plot of resistivity of copper as a function of temperature. 3

(b) (i) "A low voltage battery from which high current is required must have low internal resistance." Justify.

(ii) "A high voltage battery must have a large internal resistance." Justify.

23. (a) When a parallel beam of light enters water surface obliquely at some angle, what is the effect on the width of the beam ? 3

(b) With the help of a ray diagram, show that a straw appears bent when it is partly dipped in water and explain it.

(c) Explain the transmission of optical signal through an optical fibre by a diagram.

24. Differentiate between the peak value and root mean square value of an alternating current. Derive the expression for the root mean square value of alternating current, in terms of its peak value. 3

25. (a) How is an electromagnetic wave produced ? 3

(b) An electromagnetic wave is travelling in vertically upward direction. At an instant, its electric field vector points in west direction. In which direction does the magnetic field vector point at that instant ?

(c) Estimate the ratio of shortest wave length of radio waves to the longest wave length of gamma waves.

26. (a) In a region of a uniform electric field $\vec{E}$, a negatively charged particle is moving with a constant velocity $\vec{v} = -v_0\hat{i}$ near a long straight conductor coinciding with XX' axis and carrying current I towards –X axis. The particle remains at a distance d from the conductor. 3

(i) Draw diagram showing direction of electric and magnetic fields.

(ii) What are the various forces acting on the charged particle ?

(iii) Find the value of v_0 in terms of E, d and I.

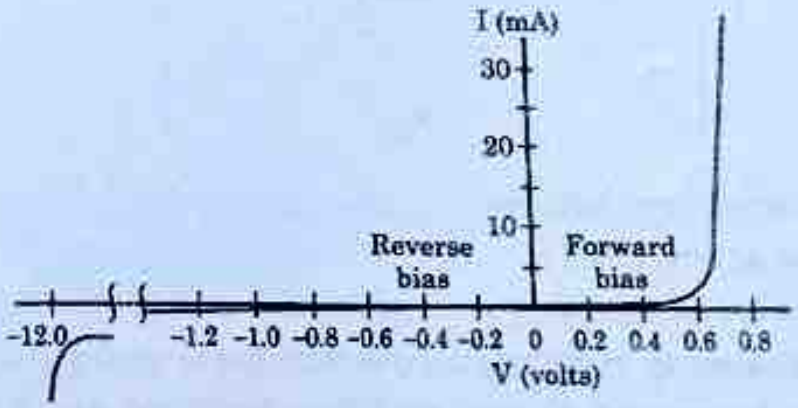
OR

(b) Two infinitely long conductors kept along XX' and YY' axes are carrying current I_1 and I_2 along –X axis and –Y axis respectively. Find the magnitude and direction of the net magnetic field produced at point P(X, Y).

27. (a) What are majority and minority charge carriers in an extrinsic semiconductor ? 3

(b) A p-n junction is forward biased. Describe the movement of the charge carriers which produce current in it.

(c) The graph shows the variation of current with voltage for a p-n junction diode.



Estimate the dynamic resistance of diode at V = –0.6 volt.

28. (a) Show the variation of binding energy per nucleon with mass number. Write the significance of the binding energy curve. 3

(b) Two nuclei with lower binding energy per nucleon form a nuclei with more binding energy per nucleon.

(i) What type of nuclear reaction is it ?

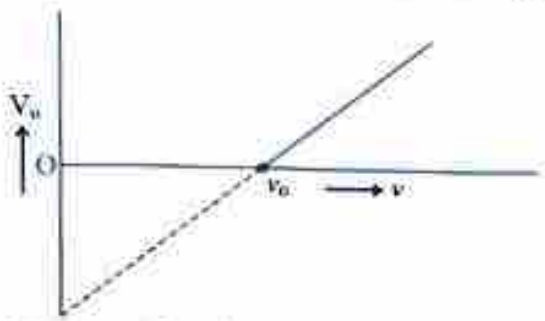
(ii) Whether the total mass of nuclei increases, decreases or remains unchanged ?

(iii) Does the process require energy or produce energy ?

SECTION – D

Question numbers **29** and **30** are case study based questions. Read the following paragraphs and answer the questions that follow.

29. When a photon of suitable frequency is incident on a metal surface, photoelectron is emitted from it. If the frequency is below a threshold frequency (ν_0) for the surface, no photoelectron is emitted. For a photon of frequency $\nu(\nu > \nu_0)$, the kinetic energy of the emitted photoelectrons is $h(\nu - \nu_0)$. The photocurrent can be stopped by applying a potential V_0 called 'stopping potential' on the anode. Thus maximum kinetic energy of photoelectrons $K_m = eV_0 = h(\nu - \nu_0)$. The experimental graph between V_0 and ν for a metal is shown in figure. This is a straight line of slope m. $4 \times 1 = 4$



(i) The straight line graphs obtained for two metals

(A) coincide each other.

(B) are parallel to each other.

(C) are not parallel to each other and cross at a point on ν-axis.

(D) are not parallel to each other and do not cross at a point on ν-axis.

(ii) The value of Planck's constant for this metal is

(A) $\frac{e}{m}$ (B) $\frac{1}{me}$

(C) me (D) $\frac{m}{e}$

(iii) The intercepts on ν-axis and V_0-axis of the graph are respectively :

(A) $\nu_0, \frac{h\nu_0}{e}$ (B) $\nu_0, h\nu_0$

(C) $\frac{h\nu_0}{e}, \nu_0$ (D) $h\nu_0, \nu_0$

OR

(iii) When the wavelength of a photon is doubled, how many times its wave number and frequency become, respectively ?

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

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

(iv) The momentum of a photon is 5.0×10^{-29} kg. m/s. Ignoring relativistic effects (if any), the wavelength of the photon is

(A) 1.33 μm (B) 3.3 μm

(C) 16.6 μm (D) 13.3 μm

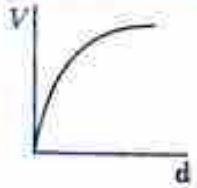
30. A parallel plate capacitor has two parallel plates which are separated by an insulating medium like air, mica, etc. When the plates are connected to the terminals of a battery, they get equal and opposite charges and an electric field is set up in between them. This electric field between the two plates depends upon the potential difference applied, the separation of the plates and nature of the medium between the plates. $4 \times 1 = 4$

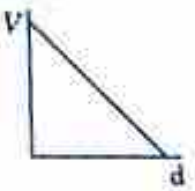
(i) The electric field between the plates of a parallel plate capacitor is E. Now the separation between the plates is doubled and simultaneously the applied potential difference between the plates is reduced to half of its initial value. The new value of the electric field between the plates will be :

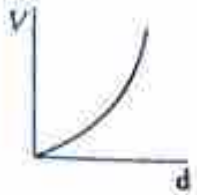
(A) E (B) 2E

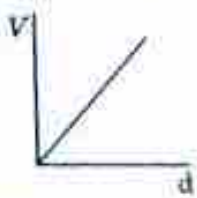
(C) $\frac{E}{4}$ (D) $\frac{E}{2}$

(ii) A constant electric field is to be maintained between the two plates of a capacitor whose separation d changes with time. Which of the graphs correctly depict the potential difference (V) to be applied between the plates as a function of separation between the plates (d) to maintain the constant electric field ?

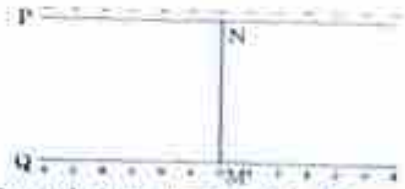
(A) 

(B) 

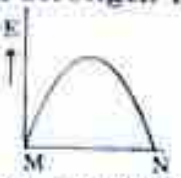
(C) 

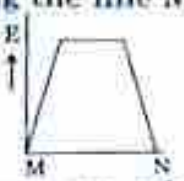
(D) 

(iii)



In the above figure P, Q are the two parallel plates of a capacitor. Plate Q is at positive potential with respect to plate P. MN is an imaginary line drawn perpendicular to the plates. Which of the graphs shows correctly the variations of the magnitude of electric field strength E along the line MN ?

(A) 

(B) 

(C) 

(D) 

(iv) Three parallel plates are placed above each other with equal displacement $\vec{d}$ between neighbouring plates. The electric field between the first pair of the plates is $\vec{E}_1$ and the electric field between the second pair of the plates is $\vec{E}_2$. The potential difference between the third and the first plate is –

(A) $(\vec{E}_1 + \vec{E}_2) \cdot \vec{d}$ (B) $(\vec{E}_1 - \vec{E}_2) \cdot \vec{d}$ (C) $(\vec{E}_2 - \vec{E}_1) \cdot \vec{d}$ (D) $\frac{d(E_1 + E_2)}{2}$

OR

(iv) A material of dielectric constant K is filled in a parallel plate capacitor of capacitance C. The new value of its capacitance becomes

(A) C (B) $\frac{C}{K}$ (C) CK (D) $C\left(1 + \frac{1}{K}\right)$

SECTION – E

31. (a) (i) A thin pencil of length (f/4) is placed coinciding with the principal axis of a mirror of focal length f. The image of the pencil is real and enlarged, just touches the pencil. Calculate the magnification produced by the mirror.

(ii) A ray of light is incident on a refracting face AB of a prism ABC at an angle of 45°. The ray emerges from face AC and the angle of deviation is 15°. The angle of prism is 30°. Show that the emergent ray is normal to the face AC from which it emerges out. Find the refraction index of the material of the prism.

OR

(b) (i) Light consisting of two wavelengths 600 nm and 480 nm is used to obtain interference fringes in a double slit experiment. The screen is placed 1.0 m away from slits which are 1.0 nm apart.

(1) Calculate the distance of the third bright fringe on the screen from the central maximum for wavelength 600 nm.

(2) Find the least distance from the central maximum where the bright fringes due to both the wavelengths coincide.

(ii) (1) Draw the variation of intensity with angle of diffraction in single slit diffraction pattern. Write the expression for value of angle corresponding to zero intensity locations.

(2) In what way diffraction of light waves differs from diffraction of sound waves ?

32. (a) (i) A small conducting sphere A of radius r charged to a potential V, is enclosed by a spherical conducting shell B of radius R. If A and B are connected by a thin wire, calculate the final potential on sphere A and shell B. 5

(ii) Write two characteristics of equipotential surfaces. A uniform electric field of 50 NC^{-1} is set up in a region along +x axis. If the potential at the origin (0, 0) is 220 V, find the potential at a point (4m, 3m).

OR

(b) (i) What is difference between an open surface and a closed surface ?

Draw elementary surface vector $d\vec{S}$ for a spherical surface S.

(ii) Define electric flux through a surface. Give the significance of a Gaussian surface. A charge outside a Gaussian surface does not contribute to total electric flux through the surface. Why ?

(iii) A small spherical shell S_1 has point charges $q_1 = -3\ \mu C$, $q_2 = -2\ \mu C$ and $q_3 = 9\ \mu C$ inside it. This shell is enclosed by another big spherical shell S_2. A point charge Q is placed in between the two surfaces S_1 and S_2. If the electric flux through the surface S_2 is four times the flux through surface S_1, find charge Q.

33. (a) (i) What is the source of force acting on a current-carrying conductor placed in a magnetic field ? Obtain the expression for force acting between two long straight parallel conductors carrying steady currents and hence define 'ampere'. 5

(ii) A point charge q is moving with velocity $\vec{v}$ in a uniform magnetic field $\vec{B}$. Find the work done by the magnetic force on the charge.

(iii) Explain the necessary conditions in which the trajectory of a charged particle is helical in a uniform magnetic field.

OR

(b) (i) A current carrying loop can be considered as a magnetic dipole placed along its axis. Explain.

(ii) Obtain the relation for magnetic dipole moment $\vec{M}$ of current carrying coil. Give the direction of $\vec{M}$.

(iii) A current carrying coil is placed in an external uniform magnetic field. The coil is free to turn in the magnetic field. What is the net force acting on the coil ? Obtain the orientation of the coil in stable equilibrium. Show that in this orientation the flux of the total field (field produced by the loop + external field) through the coil is maximum.