Series GEFH1/5

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 23 हैं ।
Please check that this question paper contains 23 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 35 प्रश्न हैं ।
Please check that this question paper contains 35 questions.

(iv) **कृपया प्रश्न का उत्तर लिखना शुरू करने से पहले, उत्तर-पुस्तिका में प्रश्न का क्रमांक अवश्य लिखें ।**
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 ।
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 35 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 18 are Multiple Choice (MCQ) type questions carrying 1 mark each.*

(iv) ***In section – B :*** *question number 19 to 25 are Short Answer-1 (SA-1) type questions carrying 2 marks each.*

(v) ***In section – C :*** *question number 26 to 30 are Short Answer-2 (SA-2) type questions carrying 3 marks each.*

(vi) ***In section – D :*** *question number 31 to 33 are Long Answer (LA) type questions carrying 5 marks each.*

(vii) ***In section – E :*** *question number 34 and 35 are case-based questions carrying 4 marks each.*

(viii) *There is no overall choice. However, an internal choice has been provided in 2 questions in Section – B, 2 questions in Section – C, 3 questions in Section – D and 2 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 $(m_e) = 9.1 \times 10^{-31}$ kg

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

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

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

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

SECTION – A

1. An electric dipole of length 2 cm is placed at an angle of 30° with an electric field 2×10^5 N/C. If the dipole experiences a torque of 8×10^{-3} Nm, the magnitude of either charge of the dipole, is 1

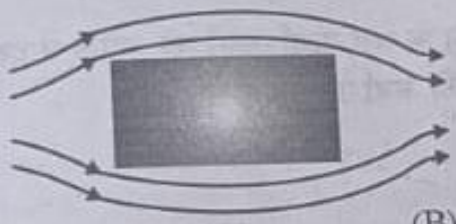
(A) 4 μC (B) 7 μC
(C) 8 mC (D) 2 mC

2. Two horizontal thin long parallel wires, separated by a distance r carry current I each in the opposite directions. The net magnetic field at a point midway between them, will be 1

(A) zero (B) $\left(\frac{\mu_0 I}{2\pi r}\right)$ vertically downward

(C) $\left(\frac{2\mu_0 I}{r}\right)$ vertically upward (D) $\left(\frac{\mu_0 I}{\pi r}\right)$ vertically downward

3. Which of the following cannot modify an external magnetic field as shown in the figure ? 1



(A) Nickel (B) Silicon
(C) Sodium Chloride (D) Copper

4. A square shaped coil of side 10 cm, having 100 turns is placed perpendicular to a magnetic field which is increasing at 1 T/s. The induced emf in the coil is 1

(A) 0.1 V (B) 0.5 V
(C) 0.75 V (D) 1.0 V

5. Which one of the following electromagnetic radiation has the least wavelength ? 1

(A) Gamma rays (B) Microwaves
(C) Visible light (D) X-rays

6. In a Young's double-slit experiment, the screen is moved away from the plane of the slits. What will be its effect on the following ? 1

(i) Angular separation of the fringes.
(ii) Fringe-width.

(A) Both (i) and (ii) remain constant.
(B) (i) remains constant, but (ii) decreases.
(C) (i) remains constant, but (ii) increases.
(D) Both (i) and (ii) increase.

P.T.O.

7. E, c and ν represent the energy, velocity and frequency of a photon. Which of the following represents its wavelength ? 1

(A) $\frac{h\nu}{c^2}$ (B) $h\nu$

(C) $\frac{hc}{E}$ (D) $\frac{h\nu}{c}$

8. The ratio of the nuclear densities of two nuclei having mass numbers 64 and 125 is 1

(A) $\frac{64}{125}$ (B) $\frac{4}{5}$

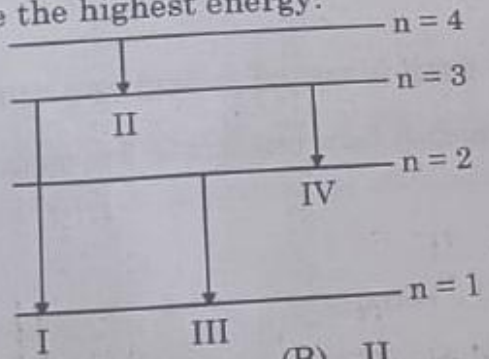
(C) $\frac{5}{4}$ (D) 1

9. The energy required by an electron to jump the forbidden band in silicon at room temperature is about 1

(A) 0.01 eV (B) 0.05 eV

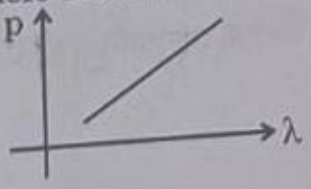
(C) 0.7 eV (D) 1.1 eV

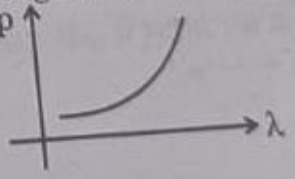
10. The diagram shows four energy level of an electron in Bohr model of hydrogen atom. Identify the transition in which the emitted photon will have the highest energy. 1



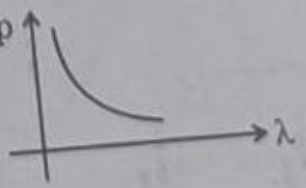
(A) I (B) II (C) III (D) IV

11. Which of the following graphs correctly represents the variation of a particle momentum with its associated de-Broglie wavelength ? 1

(A)


(B)


(C)


(D)


P.T.O.

12. The capacitors, each of 4 μF are to be connected in such a way that the effective capacitance of the combination is 6 μF. This can be achieved by connecting 1

(A) All three in parallel

(B) All three in series

(C) Two of them connected in series and the combination in parallel to the third.

(D) Two of them connected in parallel and the combination in series to the third.

13. What is the ratio of inductive and capacitive reactance in an ac circuit ? 1

(A) $\omega^2 LC$ (B) LC^2

(C) $\frac{LC}{\omega^2}$ (D) $\omega^2 L$

14. In an interference experiment, third bright fringe is obtained at a point on the screen with a light of 700 nm. What should be the wavelength of the light source in order to obtain the fifth bright fringe at the same point ? 1

(A) 420 nm (B) 750 nm

(C) 630 nm (D) 500 nm

15. The radius of the n^{th} orbit in Bohr model of hydrogen atom is proportional to 1

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

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

Note : In question number **16** to **18** two statements are given – one labelled **Assertion (A)** and the other labelled **Reason (R)**. Select the correct answer to these questions from the codes **(a)**, **(b)**, **(c)** and **(d)** as given below :

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

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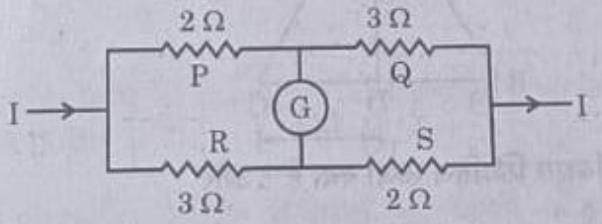
16. **Assertion (A)** : The resistance of an intrinsic semiconductor decreases with increase in its temperature. 1

Reason (R) : The number of conduction electrons as well as hole increase in an intrinsic semiconductor with rise in its temperature.

17. **Assertion (A)** : The given figure does not show a balanced Wheatstone bridge. 1



Reason (R) : For a balanced bridge small current should flow through the galvanometer.

18. **Assertion (A)** : The deflecting torque acting on a current carrying loop is zero when its plane is perpendicular to the direction of magnetic field. 1

Reason (R) : The deflecting torque acting on a loop of magnetic moment $\vec{m}$ in a magnetic field $\vec{B}$ is given by the dot product of $\vec{m}$ and $\vec{B}$.

SECTION – B

19. Plot a graph showing the variation of photo electric current, as a function of anode potential for two light beams having the same frequency but different intensities I_1 and I_2 ($I_1 > I_2$). Mention its important features. 2

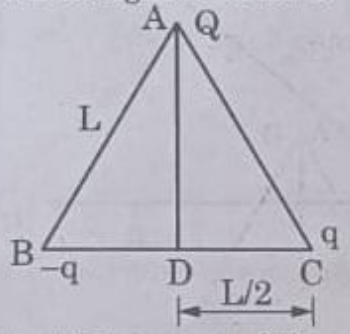
20. (a) How will the De Broglie wavelength associated with an electron be affected when the (i) velocity of the electron decreases ? and (ii) accelerating potential is increased ? Justify your answer. 2

OR

(b) How would the stopping potential for a given photosensitive surface change if (i) the frequency of the incident radiation were increased ? and (ii) the intensity of incident radiation were decreased ? Justify your answer. 2

21. How are electromagnetic waves produced ? Write their two characteristics. 2

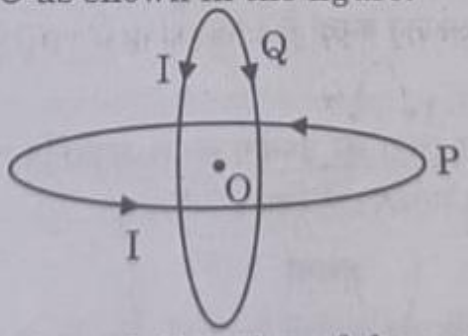
22. Three point charges Q, q and – q are kept at the vertices of an equilateral triangle of side L as shown in figure. What is 2



(i) the electrostatic potential energy of the arrangement ? and

(ii) the potential at point D ?

23. (a) Two identical circular loops P and Q, each of radius R carrying current I are kept in perpendicular planes such that they have a common centre O as shown in the figure.



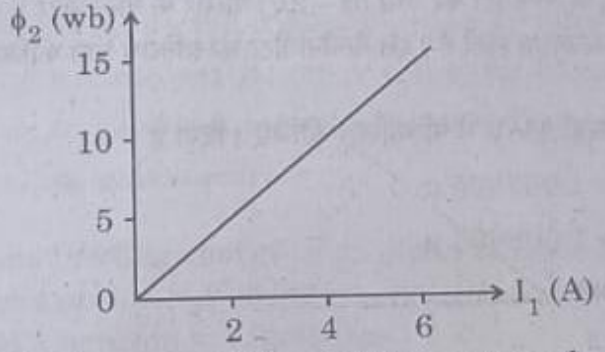
Find the magnitude and direction of the net magnetic field at point O. 2

OR

(b) A long straight conductor kept along X' X axis, carries a steady current I along + x direction. At an instant t, a particle of mass m and charge q at point (x, y) moves with a velocity $\vec{v}$ along + y direction. Find the magnitude and direction of the force on the particle due to the conductor. 2

24. Two conductors, made of the same material have equal lengths but different cross-sectional areas A_1 and A_2 ($A_1 > A_2$). They are connected in parallel across a cell. Show that the drift velocities of electrons in two conductors are equal. 2

25. Two coils C_1 and C_2 are placed close to each other. The magnetic flux ϕ_2 linked with the coil C_2 varies with the current I_1 flowing in coil C_1, as shown in the figure. Find 2



(i) the mutual inductance of the arrangement, and

(ii) the rate of change of current $\left(\frac{dI_1}{dt}\right)$ that will induce an emf of 100 V in coil C_2.

SECTION – C

26. (a) A plane wave-front propagating in a medium of refractive index 'μ_1' is incident on a plane surface making an angle of incidence (i). It enters into a medium of refractive index μ_2 ($\mu_2 > \mu_1$).

Use Huygen's construction of secondary wavelets to trace the retracted wave-front. Hence verify Snell's law of refraction. 3

OR

(b) Using Huygen's construction, show how a plane wave is reflected from a surface. Hence verify the law of reflection. 3

P.T.O.

27. An alternating current $I = 14 \sin (100 \pi t)$ A passes through a series combination of a resistor of 30 Ω and an inductor of $\left(\frac{2}{5\pi}\right)$ H. Taking $\sqrt{2} = 1.4$, calculate the

(i) rms value of the voltage drops across the resistor and the inductor, and

(ii) power factor of the circuit. 3

28. State the basic principle behind the working of an ac generator. Briefly describe its working and obtain the expression for the instantaneous value of emf induced. 3

29. (a) Briefly describe how the current sensitivity of a moving coil galvanometer can be increased.

(b) A galvanometer shows full scale deflection for current I_g. A resistance R_1 is required to convert it into a voltmeter of range (0 – V) and a resistance R_2 to convert it into a voltmeter of range (0 – 2V). Find the resistance of the galvanometer. 3

30. (a) Calculate the binding energy of an alpha particle in MeV. Given 3

mass of a proton = 1.007825 u
mass of a neutron = 1.008665 u
mass of He nucleus = 4.002800 u
$1u = 931 \text{ MeV}/c^2$

OR

(b) A heavy nucleus P of mass number 240 and binding energy 7.6 MeV per nucleon splits into two nuclei Q and R of mass number 110 and 130 and binding energy per nucleon 8.5 MeV and 8.4 MeV respectively. Calculate the energy released in the fission. 3

SECTION – D

31. (a) Draw the circuit arrangement for studying V-I characteristics of a p-n junction diode in (i) forward biasing and (ii) reverse biasing. Draw the typical V-I characteristics of a silicon diode. Describe briefly the following terms : (i) minority carrier injection in forward biasing and (ii) breakdown voltage in reverse biasing. 5

OR

(b) Name two important processes involved in the formation of a p-n junction diode. With the help of a circuit diagram, explain the working of junction diode as a full wave rectifier. Draw its input and output waveforms. State the characteristic property of a junction diode that makes it suitable for rectification. 5

32. (a) (i) Draw a ray diagram to show the working of a compound microscope. Obtain the expression for the total magnification for the final image to be formed at the near point. 3

(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. If the eye-piece has a focal length of 5 cm and the final image is formed at the near point, find the magnifying power of the microscope. 2

OR

(b) (i) Draw a ray diagram for the formation of image of an object by an astronomical telescope, in normal adjustment. Obtain the expression for its magnifying power.

(ii) The magnifying power of an astronomical telescope in normal adjustment is 2.9 and the objective and the eyepiece are separated by a distance of 150 cm. Find the focal lengths of the two lenses. 5

33. (a) (i) Explain how free electrons in a metal at constant temperature attain an average velocity under the action of an electric field. Hence obtain an expression for it. 3

(ii) Consider two conducting wires A and B of the same diameter but made of different materials joined in series across a battery. The number density of electrons in A is 1.5 times that in B. Find the ratio of drift velocity of electrons in wire A to that in wire B. 2

OR

(b) (i) A cell emf of (E) and internal resistance (r) is connected across a variable load resistance (R). Draw plots showing the variation of terminal voltage V with (i) R and (ii) the current (I) in the load. 2

(ii) Three cells, each of emf E but internal resistances 2r, 3r and 6r are connected in parallel across a resistor R.

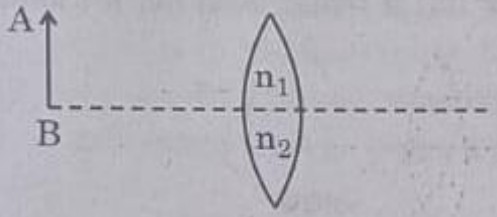
Obtain expressions for (i) current flowing in the circuit, and (ii) the terminal potential difference across the equivalent cell. 3

SECTION – E

Note : Questions number **34** and **35** are Case Study based questions. Read the following paragraph and answer the questions.

34. A lens is a transparent optical medium bounded by two surfaces; at least one of which should be spherical. Considering image formation by a single spherical surface successively at the two surfaces of a lens, lens maker's formula is obtained. It is useful to design lenses of desired focal length using surfaces of suitable radii of curvature. This formula helps us obtain a relation between u, v and f for a lens. Lenses form images of objects and they are used in a number of optical devices, for example microscopes and telescopes. 4

(i) An object AB is kept in front of a composite convex lens, as shown in figure. Will the lens produce one image ? If not, explain.



(ii) A real image of an object formed by a convex lens is observed on a screen. If the screen is removed, will the image still be formed ? Explain.

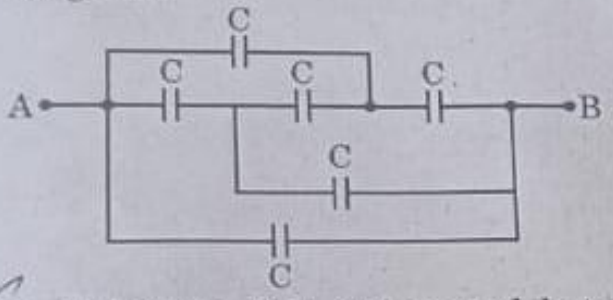
(iii) A double convex lens is made of glass of refractive index 1.55 with both faces of the same radius of curvature. Find the radius of curvature required if focal length is 20 cm.

OR

(iii) Two convex lenses A and B of focal lengths 15 cm and 10 cm respectively are placed coaxially 'd' distance apart. A point object is kept at a distance of 30 cm in front of lens A. Find the value of 'd' so that the rays emerging from lens B are parallel to its principal axis.

35. A capacitor is a system of two conductors separated by an insulator. The two conductors have equal and opposite charges with a potential difference between them. The capacitance of a capacitor depends on the geometrical configuration (shape, size and separation) of the system and also on the nature of the insulator separating the two conductors. They are used to store charges. Like resistors, capacitors can be arranged in series or parallel or a combination of both to obtain desired value of capacitance. 4

(i) Find the equivalent capacitance between points A and B in the given diagram.

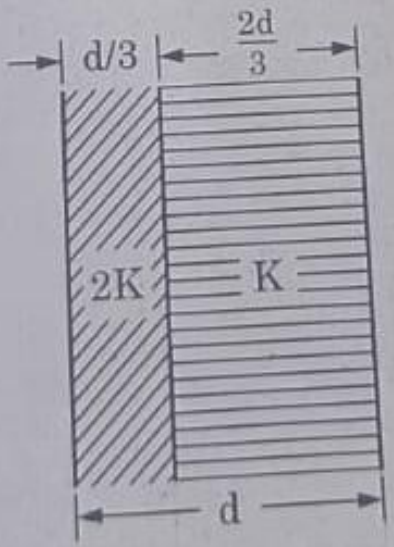


(ii) A dielectric slab is inserted between the plates of a parallel plate capacitor. The electric field between the plates decreases. Explain.

(iii) A capacitor A of capacitance C, having charge Q is connected across another uncharged capacitor B of capacitance 2C. Find an expression for (a) the potential difference across the combination and (b) the charge lost by capacitor A.

OR

(iii) Two slabs of dielectric constants 2K and K fill the space between the plates of a parallel plate capacitor of plate area A and plate separation d as shown in figure. Find an expression for capacitance of the system.



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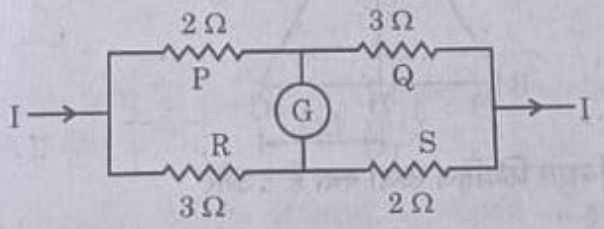

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