Roll Number						

Set - 01

SAHODAYA PREBOARD EXAMINATION, 2024-25

- Please check that this question paper contains 09 printed pages.
- Please check that this question paper contains 33 questions.
- Please write down the Serial Number of the question before attempting it.
- 15 minute time has been allotted to read this question paper. The students will read the question paper only during this time and will not write any answer on the answer-book during this period.

PHYSICS (042)

Time Allowed: 3 hours ***Maximum Marks: 70***

General Instructions:

(1) There are 33 questions in all. All questions are compulsory.
(2) This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
(3) All the sections are compulsory.
(4) Section A contains sixteen questions, twelve MCQ and four Assertion Reasoning based of 1 mark each, Section B contains five questions of two marks each, Section C contains seven questions of three marks each, Section D contains two case study-based questions of four marks each and Section E contains three long answer questions of five marks each.
(5) There is no overall choice. However, an internal choice has been provided in one question in Section B, one question in Section C, one question in each CBQ in Section D and all three questions in Section E. You must attempt only one of the choices in such questions.
(6) Use of calculators is not allowed.
(7) You may use the following values of physical constants wherever necessary
i. $c = 3 \times 10^8$ m/s
ii. $m_e = 9.1 \times 10^{-31}$ kg
iii. $m_p = 1.7 \times 10_{-27}$ kg
iv. $e = 1.6 \times 10^{-19}$ C
v. $\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}
vi. $h = 6.63 \times 10^{-34}$ J s

vii. $\varepsilon_0 = 8.854 \times 10^{-12}\ C^2N^{-1}M^{-2}$

viii. Avogadro's number = 6.023×10^{23} per gram mole

(8) No overwriting and cutting in MCQs answers are allowed. If so zero mark will be awarded in that question. Write the correct options with answers in MCQs clearly. Draw the relevant diagrams wherever necessary with required derivations.

SECTION - A

1. A conducting sphere of radius R is given a charge Q. Consider three points 'B' at the surface, 'A' at centre and 'C' at a distance R/2 from the centre. The electric potential at these points are such that: 1

(a) $V_A = V_B = V_C$ (b) $V_A = V_B \neq V_C$ (c) $V_A \neq V_B \neq V_C$ (d) $V_A \neq V_B = V_C$

2. Two charge spherical conductors of radius x_1 and x_2 are connected by a conducting wire. Then the ratio of surface charge densities of the sphere σ_1 *and* σ_2 is: 1

(a) $\frac{x_1}{x_2}$ (b) $\frac{x_2}{x_1}$ (c) $\sqrt{\frac{x_1}{x_2}}$ (d) $\frac{x_1^2}{x_2^2}$

3. A current carrying circular loop of radius 'r' is placed in the x-y plane with centre at the origin. Half of the loop with x > 0 is now bent, so that it now lies in the y-z plane. Which of the following statement is correct about the later situation? 1

(a) The magnetic moment does not change.
(b) The magnitude of magnetic moment now decreases.
(c) The magnitude of $\vec{B}$ at (0, 0, z), z >> r increases.
(d) The magnitude of $\vec{B}$ at (0, 0, z), z >> r remains unchanged.

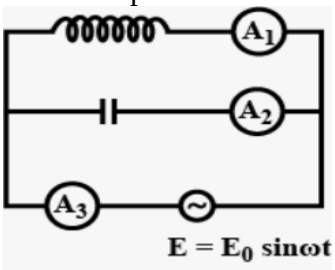
4. Consider the diffraction pattern for a small pinhole as the site of the hole is increased, then in the diffraction pattern 1

(a)the size decreases (b) the size increases
(c) the intensity increases (d) the intensity decreases

5. A capacitor of 100Ω reactance & a 100Ω resistance are connected in series across a 220 V source. When the capacitor is 25% charged, the peak value of the displacement current is: 1

(a) 4.4 A (b) 2.2 A (c)11 A (d) $11\sqrt{2}$ A

6. An inductor of 12 mH and a capacitor of 18 μF are connected in the circuit as shown in the figure. The frequency of the power supply is equal to the resonant frequency of the circuit. Which ammeter will read zero ampere. 1



(a) A_1 (b) A_2 (c) A_3 (d) None of these

7. Correct match of column I with column II is: 1

Column -I (waves)	Column -II (Detection)
(1) Light	P. Geiger tubes
(2) X-ray	Q. Photocells
(3) Gamma rays	R. The eye
(4) Ultra violet	S. Ionisation chamber

(a) 1-P, 2-Q, 3-R, 4-S (b) 1-S, 2-Q, 3-P, 4-R
(c) 1-R, 2-P, 3-Q, 4-S (d) 1-R, 2-P, 3-S, 4-Q

8. On applying a potential difference of V volt on a proton, a wave of wavelength λ is obtained. The voltage applied to a triton to produce the same wavelength will be: 1

(a) $\frac{V}{3}$ volt (b) V volt (c) $\frac{V}{9}$ volt (d) 2V volt

9. A beam of light converges at a point 'p'. Now a convex lens of focal length 20 cm is placed in the path of the convergent beam at 12 cm from P. The position at which beam converges is 1

(a) $\frac{60}{8}cm$ (b) $\frac{70}{8}cm$ (c) $\frac{90}{8}cm$ (d) $\frac{50}{8}cm$

10. A beam of wavelength of light λ nm from a distance source falls on a single slit 'y' mm wide and the resulting diffraction pattern is observed on a screen 'x' m away. The linear distance between the first dark fringe on either side of the central bright fringe is: 1

(a) $\frac{y\lambda}{x}$ (b) $\frac{x\lambda}{2y}$ (c) $\frac{x}{\lambda y}$ (d) $\frac{2x\lambda}{y}$

11. In an unbiased p-n junction at equilibrium, which of the following statements is true about diffusion current and drift current? 1
(a)Diffusion current is equal to drift current
(b)Drift current exists while diffusion current is zero
(c) Diffusion current exists while drift current is zero
(d) Neither drift current nor diffusion current exists

12. A primary cell of emf of 1.4 volts, when short-circuited, it gives a current of 2.8 ampere. The internal resistance of the cell is: 1
(a)5.2 Ω (b) 1.4 Ω (c) 0.5 Ω (d) 2 Ω

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 options as given below.
A. If both Assertion and Reason are true and Reason is the correct explanation of Assertion.
B. If both Assertion and Reason are true but Reason is not the correct explanation

of Assertion.
C. If Assertion is true but Reason is false.
D. If both Assertion and Reason are false.

13. **Assertion(A):** A galvanometer can't be used as an ammeter to measure the current across the given section of the circuit. 1
Reason(R): For this it must be connected in series with the circuit.

14. **Assertion(A):** Between any two given energy level the number of absorption transitions is almost always less than the number of emission transitions. 1
Reason(R): Absorption transition starts from the lowest energy level only and may end at any higher energy level but emission transition may start from any higher energy level and at any energy level below it.

15. **Assertion(A):** The nucleus ${}^{7}_{3}X$ is more stable than the nucleus ${}^{4}_{3}Y$. 1
Reason(R): ${}^{7}_{3}X$ contains more number of protons.

16. **Assertion(A):** The photoelectrons produced by a monochromatic light beam incident on a metal surface have a spread in their kinetic energies. 1
Reason(R): The energy of electrons emitted from inside the metal surface, is lost in collision with the other atoms in the metal.

SECTION – B

17. In a photoelectric experiment, ultraviolet light of wavelength 280 nm is used with lithium cathode having work function $\phi = 2.5eV$. If the wavelength of incident light is switched to 400 nm, find out the change in the stopping potential. 2

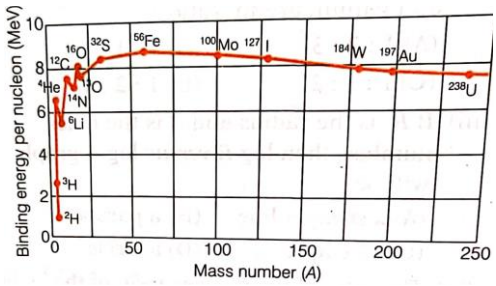
18. In Young's double slit experiment, the slits are separated by 0.3 mm and the screen is 1.5 m away from the plane of slits. Distance between fourth bright fringes on both sides of central bright fringe is 2.4 cm. Find the frequency of light used. 2

OR

White light is passed through a double slit and interference is observed on a screen 1.5 m away. The separation between the slits is 0.3 mm. The first violet and red fringes are formed 2.0 mm and 3.5 mm away from the central white fringe. Find the difference in wavelengths of red and violet light in nm.

19. An electron after being accelerated through a potential difference of 10^4 V enters a uniform magnetic field of 0.04 T perpendicular to its direction of motion. Calculate the radius of curvature of its trajectory. 2

20. Given here is BE/nucleon versus mass number curve. 2



(i) Arrange the following nuclei in the ascending order of the ease with which a nucleon can be taken out of the atomic nucleus: ^{6}Li, ^{16}O, ^{56}Fe *and* ^{238}U.

(ii) If 8 protons and 8 neutrons are combined into the following nuclei/combination of nuclei, estimate which one of them will release the most energy? Show the working.

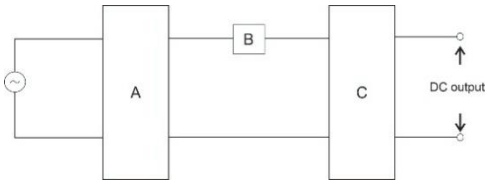
(a) One ^{12}C nucleus and one ^{4}He nucleus

(b) Four ^{4}He nuclei

21. When an electron in hydrogen atom jumps from the third excited state to the ground state, how would the de-Broglie wavelength have associated with the electron change? Justify your answer. 2

SECTION – C

22. (i) Identify the circuit elements A, B & C in the following block diagram and draw the output wave forms. 3



(ii) In half-wave rectification, what is the output frequency, if the input frequency is 50 Hz? What is the output frequency of a full wave rectifier for the same input frequency?

23. Derive the expression for the capacitance of a parallel plate capacitor. What will happen if the space between the plates is completely filled by a dielectric of constant 'K'? 3

24. Through a ray diagram, show the image formation by a reflecting type of telescope. Mention any two advantages of this telescope. 3

25. Draw the following: 3

(i) Barrier potential without battery and with low battery voltage under forward bias.

(ii) Energy band diagram of intrinsic semiconductor at 0K.

(iii) Energy band diagram of p-type semiconductor at room temperature.

26. (i) A circular coil of 30 turns and radius 8.0 cm carrying a current of 6.0 A is suspended vertically in a uniform horizontal magnetic field of magnitude 1.0 T. The field lines make an angle of 60º with the normal of the coil. Calculate the magnitude of the counter torque that must be applied to prevent the coil from turning. 3

(ii) Would your answer change, if the circular coil in (i) were replaced by a planar coil of some irregular shape that encloses the same area? (All other particulars are also unaltered.)

27. The refractive index of a material of a concave lens is n_1. It is immersed in a medium of refractive index n_2. A parallel beam of light is incident on the lens. Trace the path of emergent rays when (i) $n_2 = n_1$ (ii) $n_2 > n_1$ (iii) $n_2 < n_1$. Justify your answer. 3

28. Using Gauss Law, derive an expression for the electric field due to an infinite long straight wire of linear charge density ' λ '. Show the E~r graph where E & r are having their usual meanings. 3

OR

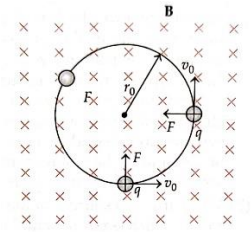
Using Gauss law, derive an expression for the electric field due to a uniformly charged infinite plane sheet. Show the E~r graph where E & r are having their usual meanings.

SECTION – D

29. **Case Based Question:** 4

(Motion of charged particle in magnetic field)

An electron with speed $v_0 << c$ moves in a circle of radius r_0 in a uniform magnetic field. This electron is able to traverse a circular path as the magnetic force acting on the electron is perpendicular to both $\vec{v}_0$ and $\vec{B}$ as shown in the figure. This force continuously deflects the particle sideways without changing its speed and the particle will move along a circle perpendicular to the field. The time required for one revolution of the electron is T_0.



(i) If the speed of the electron is now doubled to $2v_0$, then the radius of the circle will

(a) $4r_0$ (b) $2r_0$ (c) r_0 (d) $r_0/2$

(ii) If $v = 2v_0$, then the time required for one revolution of the electron (T_0) will change to

(a) $4T_0$ (b) $2T_0$ (c) T_0 (d) $T_0/2$

(iii) A charged particles is projected in a magnetic field $\vec{B} = (2\hat{i} + 4\hat{j}) \times 10^2 T$. The acceleration of the particle is found to be $a = (x\hat{i} + 2\hat{j}) m/s^2$. Find the value of x.

(a) $4ms^{-2}$ (b) $-4ms^{-2}$ (c) $-2ms^{-2}$ (d) $2ms^{-2}$

(iv) If the given electron has a velocity not perpendicular to B, then trajectory of the electron is

(a)straight line (b) circular (c) helical (d) zig-zag

OR

If this electron of charge (e) is moving parallel to uniform magnetic field with constant velocity v, the force acting on the electron is

(a)Bev (b) Be/v (c) B/ev (d) zero

30. **Case Based Question:** 4

Matter Wave (de-Broglie Wave)

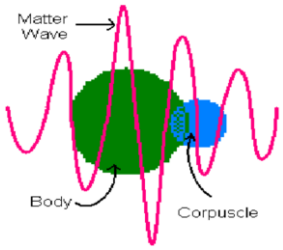
de-Broglie proposed that the wavelength λ associated with a particle of momentum p is given as $\lambda = \frac{h}{p} = \frac{h}{mv}$

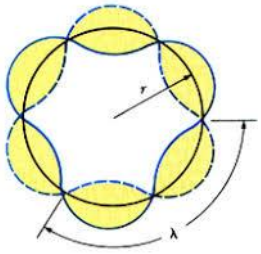
Where m is the mass of the particle and v its speed. Given equation is known as the de-Broglie relation and the wavelength λ of the matter wave is called de-Broglie wavelength. The dual aspect of matter is evident in the de-Broglie relation.

Above equation for a material particle is basically a hypothesis whose validity can be tasted only by experiment. However, it is interesting to see that it is also satisfied by a photon. For a photon, as we have seen,

$p = \frac{h\upsilon}{c}$

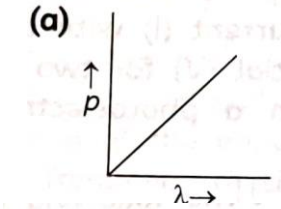
Therefore, $\frac{h}{p} = \frac{c}{\upsilon} = \lambda$

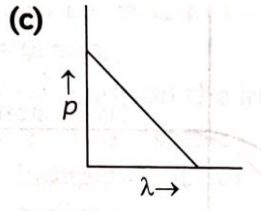


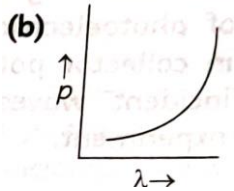


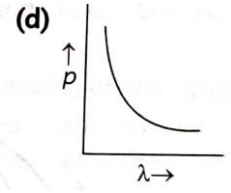
(i) A particle moves in a closed orbit around the origin, due to a force which is directed towards the origin. The de-Broglie wavelength of the particle varies cyclically between two values λ_1, λ_2 with $\lambda_1 > \lambda_2$. Which of the following statements is true?
(a) The particle could be moving in a circular orbit with origin as centre.
(b) The particle could be moving in a circular orbit with its centre on x-axis.
(c) When the de-Broglie wavelength is λ_1, the particle is nearer the origin than when its value is λ_2.
(d) When the de-Broglie wavelength is λ_2, the particle is nearer the origin than when its value is λ_1.

(ii) Which of the following figures represent the variation of particle momentum and the associated de-Broglie wavelength:









(iii) The de-Broglie wavelength of an electron moving with a speed of 6.6 x 10^5 m/s is nearly equal to:

(a) 10^{-11} m (b) 10^{-9} m (c) 10^{-7} m (d) 10^{-5} m

(iv) The wavelength of photon is proportional to (where ν = frequency):

(a) ν (b) $\sqrt{\nu}$ (c) $\frac{1}{\sqrt{\nu}}$ (d) $\frac{1}{\nu}$

OR

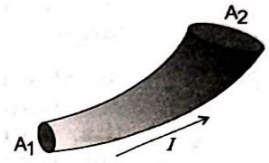
If we consider electrons and photons of same wavelength, then they will have same:

(a) energy (b) velocity (c) momentum (d) angular momentum

SECTION – E

31. (i) State Ohm's law in microscopic form. Derive the appropriate expression for it. 5

(ii) For a current-carrying conductor of changing diameter as shown below, how does each of the following quantities vary along the two ends of conductor with area of cross sections A_1 and A_2? Give an explanation for each.



(a)Current

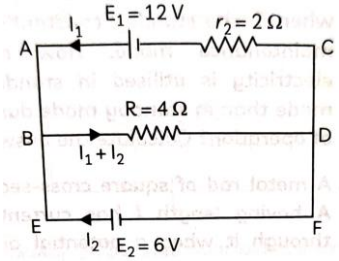
(b) Current density

(c) Potential drop

OR

(i) State and explain Kirchhoff's laws.

(ii) In the electric network shown in the figure use Kirchhoff's law to calculate the power, consumed by the resistance R=4Ω.



32. (i) With the help of a labelled diagram, describe the principle and working of an AC generator. Hence obtain an expression for the instantaneous value of the emf generated. 5

(ii) The coil of an AC generator consists of 100 turns of wire, each of area 0.5 m^2. The resistance of the wire is 100Ω. The coil is rotated in a magnetic field of 0.8T perpendicular to its axis of rotation, at a constant angular speed of 60 radian per second. Calculate the maximum emf generated and power dissipated in the coil.

OR

(i) Draw the diagram of a device which is used to decrease high AC voltage into a low AC voltage. Deduce the expression for its working principle and explain.

(ii) A small town with a demand of 1200 kW of electric power at 220 V is situated 20 km away from an electric plant generating power at 440 V. The resistance of the two wire line carrying power is 0.5 Ω per km. The town gets the power from the line through a 4000-220 V step-down transformer at a sub-station in the town. Estimate the line power loss in the form of heat.

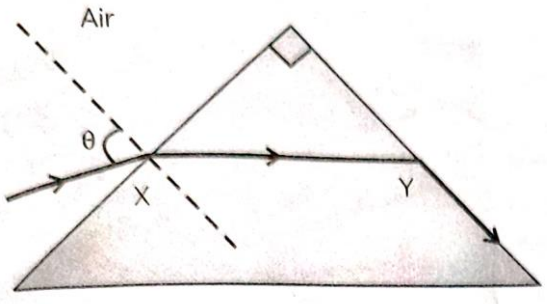
33. (i) Draw a ray diagram showing the image formation by a compound microscope when 5

the final image is formed at the least distance of distinct vision (LDDV). Derive an expression for the total magnification when the final image is formed at the near point (LDDV).

(ii) A compound microscope has an objective of focal length 1.25 cm and eyepiece of focal length 5 cm. A small object is kept at 2.5 cm from the objective. If the final image formed is at infinity, find the distance between the objective and the eyepiece.

OR

(i) A ray of light is incident at an angle θ on a right angled prism at 'X'. At point 'Y' it emerges along the prism surface. Find the refractive index of the prism in terms of the incident angle.



(ii) Show that for an equilateral prism kept in air, minimum deviation occurs when the angle of incidence $i = \sin^{-1}\frac{\mu}{2}$, where μ is the refractive index of the material of the prism

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