VELAMMAL NEXUS SCHOOLS (CBSE)

CHENNAI

HALF YEARLY EXAMINATION (2024-25)

Class : XII
Subject : Physics (Paper-I)
Duration : 3 Hours
Exam No. : 12A33

Total Marks : 70
Code : 042
Date : 09/11/24
Invigilator's Signature: _____

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 have to 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 where ever necessary
   i. $c = 3 \times 10^8$ m/s
   ii. $m_e = 9.1 \times 10^{-31}$ kg
   iii. $e = 1.6 \times 10^{-19}$ C
   iv. $\mu_0 = 4\pi \times 10^{-7}$ TmA^{-1}
   v. $h = 6.63 \times 10^{-34}$ Js
   vi. $\varepsilon_0 = 8.854 \times 10^{-12}$ $C^2N^{-1}m^{-2}$
   vii. Avogadro's number = 6.023×10^{23} per gram mole

SECTION – A (16 x 1 = 16)

1. An AC source V = 282 sin (100t) V is connected across a 1 μF capacitor. The rms value of current in the circuit will be _____.

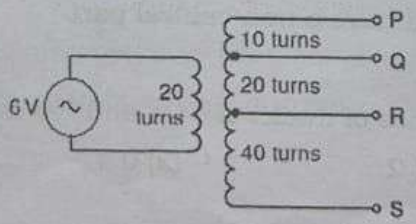
   (a) 10 mA (b) 20 mA (c) 40 mA (d) 80 mA

2. In L-C-R circuit, the capacitance is changed from C to 4C. For the same resonant frequency, the inductance should be changed from L to _____.

   (a) 2L (b) L/2 (c) L/4 (d) 4L

3. The number of turns between each pair of output terminals of a transformer is shown in the diagram. Between which two terminals will be output be 12 V.

   (a) P & Q
   (b) Q & R
   (c) R & S
   (d) P & R



4. A sinusoidal voltage V(t) = 100 sin (500t) is applied across a pure inductance of L = 0.02 H. The current through the coil is _____.

(a) 10 cos (500t) (b) – 10 cos (500t) (c) 10 sin (500t) (d) – 10 sin (500t)

5. When light travels from one medium to the other medium of which the refractive index is different, then which of the following will change

(a) frequency, wavelength and velocity (b) frequency and wavelength

(c) frequency and velocity (d) wavelength and velocity

6. A concave mirror for face viewing has focal length of 0.4 m. The distance at which you hold the mirror from your face in order to see your image upright with a magnification of 5 is _____.

(a) 0.32 m (b) 0.24 m (c) 1.60 m (d) 0.16 m

7. A biconvex lens has radii of curvature 20 cm each. If the refractive index of the material of the lens is 1.5. The power of the lens is _____.

(a) +2D (b) +20D (c) +5D (d) infinity

8. In order to increase the angular magnification of a simple microscope, one should increase _____.

(a) the object size (b) the aperture of the lens

(c) the focal length of the lens (d) the power of the lens

9. The radius of $^{27}_{13}X$ nucleus is R. The radius of $^{125}_{53}Y$ nucleus will be _____.

(a) $\frac{5}{3}R$ (b) $\left(\frac{13}{53}\right)^{1/3}R$ (c) $\left(\frac{5}{3}R\right)^{1/3}$ (d) $\left(\frac{13}{53}R\right)^{1/3}$

10. Nuclear force are _____.

(a) spin dependent and have no non-central part

(b) spin dependent and have a non-central part

(c) spin independent and have no non-central part

(d) spin independent and have a non-central part

11. The ratio of mass densities of nuclei of ^{40}Ca and ^{16}O is close to _____.

(a) 1 (b) 2 (c) 0.1 (d) 5

12. Consider the nuclear fission $Ne^{20} \rightarrow 2He^4 + C^{12}$

Give that the binding energy / nucleon of Ne^{20}, He^4 and C^{12} are 8.03 MeV, 7.07 MeV and 7.86 MeV respectively. Identify the correct statement.

(a) Energy of 9.72 MeV has to be supplied.

(b) Energy of 12.4 MeV will be supplied.

(c) 8.3 MeV energy will be released.

(d) Energy of 3.6 MeV will be released.

Questions No. 13 to 16 are Assertion (A) and Reason (R) type questions. Two statements are given – one labelled as Assertion (A) and the other labelled as Reason (R). Select the correct answer from the codes (A), (B), (C) and (D) as given below.

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

(b) Both A and R are true and R is not the correct explanation of A.

(c) A is true but R is false.

(d) both A and R are false.

13. **Assertion (A):** Binding energy per nucleon is practically constant for middle mass numbers ($30 < A < 170$).

Reason (R): Nuclear force is short ranged in nature.

14. **Assertion (A):** The degree of convergence of a convex lens made of glass decreases when it is placed in water.

Reason (R): The relative refractive index of glass with respect to water is less than that of glass with air.

15. **Assertion (A):** The angle of minimum deviation for a prism is lesser for red light than that for blue light.

Reason (R): The refractive index of the material of a prism for blue light is greater than that for red light.

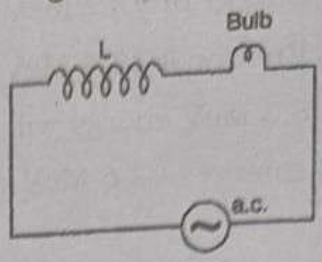
16. **Assertion (A):** It is advantageous to transmit electric power at high voltage.

Reason (R): High voltage implies high current.

SECTION – B

(5 x 2 = 10)

17. An inductor 'L' of reactance X_L is connected in series with a bulb 'B' to an a.c source shown in figure. Briefly explain how does the brightness of the bulb change when



(i) number of turns of the inductor is reduced

(ii) a capacitor of reactance $X_C = X_L$ is included in series in the same circuit.

18. (i) What is the value of power factor of a series LCR circuit at resonance?

(ii) What is Wattless current?

19. (i) Draw a labelled ray diagram of compound microscope, when final image forms at the least distance of distinct vision.

(ii) Why is its objective of short focal length and of short aperture, compared to its eye piece? Explain.

20. Draw a graph showing the variation of potential energy of a pair of nucleons as a function of their separation. Indicate the region in which the nuclear force is

(i) attractive

(ii) repulsive.

21. Complete the following reactions:

(i) ${}_5B^{10} + {}_0n^1 \rightarrow {}_2He^4 + \_\_\_\_\_$

(ii) ${}^{94}_{42}Mo + {}^{2}_{1}H \rightarrow {}^{}_{43}Te^{95} + \_\_\_\_\_$

(OR)

Obtain the binding energy of the nuclei ${}_{26}Fe^{56}$ in units of MeV from the following data. $m_H = 1.007825$ amu ; $m_n = 1.008665$ amu, $m\ ({}_{26}Fe^{56}) = 55.934939$ amu; 1 amu = 931.5 MeV.

SECTION – C

(7 x 3 = 21)

22. The primary coil of an ideal step-up transformer has 100 turns and the transformation ratio is also 100. The input voltage and the power are 220 V and 1100 W respectively. Calculate

(i) number of turns in the secondary

(ii) the current in the primary

(iii) the voltage across the secondary

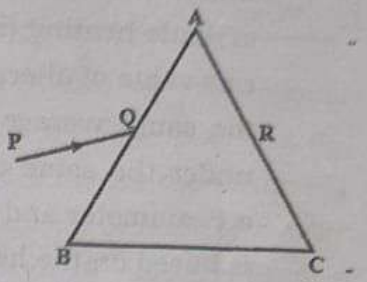
(iv) the current in the secondary

(v) power in the secondary.

23. An a.c voltage $V = V_0 \sin \omega t$ is applied across an inductance L. Obtain an expression for the current I. Show the phase relationship between current and voltage in a phasor diagram. What is inductive reactance?

24. Derive the expression for mirror equation and also its linear magnification with neat diagram.

25. A ray PQ incident on the face AB of a prism ABC, as shown in the figure, emerges from the face AC such that AQ = AR. Draw the ray diagram showing the passage of the ray through the prism. If the angle of the prism is 60° and refractive index of the material of the prism is $\sqrt{3}$, determine the value of angle of incidence and angle of deviation.



26. (i) Draw a labelled diagram of refraction type telescope in normal adjustment.
(ii) Give its two short comings over reflection type telescope.
(iii) Why is eyepiece of a telescope of short focal length, while objective is of large focal length? Explain.

27. (i) Distinguish between nuclear fission and nuclear fusion. Show how in both of these processes energy is released.
(ii) Calculate the energy released in MeV in the deuterium – tritium fusion reaction.

$${}_1H^2 + {}_1H^3 \rightarrow {}_2He^4 + {}_0n^1$$

Using the data,

$m\,({}_1H^2) = 2.014102$ u; $m\,({}_2He^4) = 4.002603$ u

$m\,({}_1H^3) = 3.016049$ u; $m_n = 1.008665$ u

$1u = 931.5\ MeV/C^2$.

28. Draw a plot showing the variation of binding energy per nucleon with mass number A. Write two important conclusions which you can draw from this plot. Explain with the help of this plot the release in energy in the processes of nuclear fusion and fission.

(OR)

(i) Suppose, we think of fission of a ${}_{26}Fe^{56}$ nucleus into two equal fragments, ${}_{13}Al^{28}$. Is the fission energetically possible? Argue by working out Q of the process. Given $m\,({}_{26}Fe^{56}) = 55.93494$ amu and $m\,({}_{13}Al^{28}) = 27.98191$ amu.
(ii) Write any two features of nuclear force.

SECTION – D

(2 x 4 = 8)

Questions no.29 and 30 are case study based questions. Read the following paragraphs and answer the questions that follows.

29. Both alternating and direct currents are measured in amperes. However, it is not possible to define a.c. ampere in terms of forces between two parallel wires carrying a.c. currents, as d.c. ampere is defined. This is because the alternating current changes direction with the source frequency and so that the net force would add up to zero. To overcome this problem, we define a.c. ampere in terms of Joule heating ($H=I^2Rt$) which is independent of direction of current. Hence the rms value of alternating current in a circuit is one ampere if the current produces the same average heating effect as one ampere of direct current would produce under the same conditions. Alternating currents and voltages are measured by a.c. ammeter and a.c. voltmeter respectively. As the working of these instruments is based on the heating effect of current, so they are called hot-wire instruments.

(i) The frequency of an alternating voltage is 50 cycles/sec and its amplitude is 120 V. Then its rms value will be _____.

(a) 84.8 V (b) 42.4 V (c) 56.5 V (d) 75.5 V

(ii) In the a.c. circuit, the current is expressed as $I = 100 \sin 200 \pi t$. In this circuit the current rises from zero to peak value in time.

(a) $\frac{1}{300}$ s (b) $\frac{1}{400}$ s (c) $\frac{1}{100}$ s (d) $\frac{1}{200}$ s

(iii) The peak value of an alternating emf ε given by $\varepsilon = \varepsilon_0 \cos \omega t$ is 10 volt and its frequency is 50 Hz. At time $t = \frac{1}{600}$ sec, the instantaneous emf is _____.

(a) 1 V (b) 5 V (c) 10 V (d) $5\sqrt{3}$ V

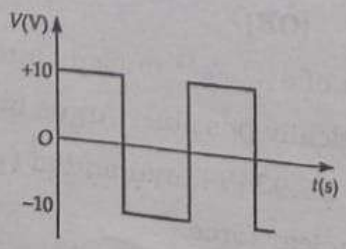
(iv) The rms value of a.c. current which when passed through a resistor produces heat energy four times that produced by d.c. of 2A through the same resistor in same time, is _____.

(a) 32 A (b) 2 A (c) 4 A (d) 8 A

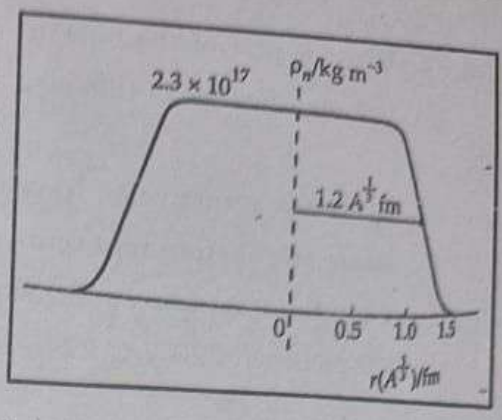
(OR)

(iv) The rms voltage of the waveform shown in the figure is _____.

(a) 10 V
(b) 12 V
(c) 6.37 V
(d) 7 V



30. A nucleus is not a solid object like a hard ball. Its surface has no clear boundary. Still we can assign a size to the nucleus. By performing high energy probes such as protons or electrons, nuclear sizes of different elements have been accurately measured. Assuming nuclei to be spherical, their volumes can be estimated. Experimental observations show that the volume of a nucleus is directly proportional to its mass number. Thus, the radius R of a nucleus is proportional to the cube root of its mass number. We can write, $R = R_0 A^{1/3}$, the constant R_0, depends on nature of probe particles. For electrons, $R_0 = 1.2$ fm. As the volume of a nucleus is proportional to the mass number A, so the density of nuclear matter is independent of the size of the nucleus. It is of the order of 10^{17} kg/m^3. Such a high density exists in neutron stars.



(i) For uranium nucleus how does its mass vary with volume ?

(a) $m \propto V$ (b) $m \propto 1/V$ (c) $m \propto \sqrt{V}$ (d) $m \propto V^2$

(ii) Order of magnitude of density of uranium nucleus [$m_p = 1.67 \times 10^{-27}$ kg] is

(a) 10^{20} kg/m^3 (b) 10^{17} kg/m^3 (c) 10^{14} kg/m^3 (d) 10^{11} kg/m^3

(iii) The mass density of a nucleus varies with mass number A as

(a) A^2 (b) A (c) constant (d) 1/A

(iv) If radius of the $_{13}Al^{27}$ nucleus is estimated to be 3.6 fermi, then the radius of $_{53}Te^{125}$ nucleus is nearly

(a) 6 fermi (b) 8 fermi (c) 4 fermi (d) 5 fermi.

(OR)

(iv) A nucleus disintegrates into two nuclear parts, which have their velocities in the ratio 2: 1. The ratio of their nuclear sizes will be

(a) $2^{1/3} : 1$ (b) $1 : 3^{1/2}$ (c) $3^{1/2} : 1$ (d) $1 : 2^{1/3}$

SECTION – E

(3 x 5 = 15)

31.(i) You are given three circuit elements X, Y and Z. When the element X is connected across an a.c source of a given voltage, the current and the voltage are in the same phase. When the element Y is connected in series with X across the source, voltage is ahead of the current in phase $\pi/4$. But the current is ahead of the voltage in phase by $\pi/4$ when Z is connected in series with X across the source. Identify the circuit elements X, Y and Z. When all the three elements are connected in series across the same source, determine the impedance of the circuit.

(ii) Draw a plot of the current versus the frequency of applied source and mention the significance of this plot.

(OR)

(i) State the principle and working of a transformer.

(ii) State two factors that reduce the efficiency of a transformer.

(iii) Calculate the current drawn by the primary of a 90% efficient transformer which steps down 220 V to 22 V, if the output resistance is 440 Ω.

32.(i) With the help of a suitable ray diagram, derive a relation between the object distance (u), image distance (v) and the radius of curvature (R) for a convex spherical surface, when a ray of light travels from rarer to denser medium.

(ii) How is the focal length of a spherical mirror affected when it is immersed in glycerine?

(OR)

A thin convex lens having two surface of radii of curvature R_1 and R_2 is made of a material of refractive index n_2. It is kept in a medium of refractive index n_1. Derive with the help of a ray diagram, the lens maker's formula when a point object placed on the principal axis in front of the radius of curvature R_1 produces an image I on the other side of the lens.

33.(i) Two thin lenses are placed coaxially in contact. Obtain the expression for the focal length of this combination in terms of the focal lengths of the two lenses.

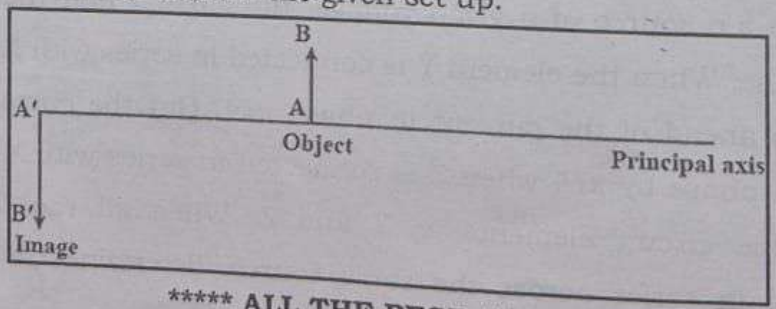
(ii) A converging lens of refractive index 1.5 has a power of 10 D. When it is completely immersed in a liquid, it behaves as a diverging lens of focal length 50 cm. Find the refractive index of the liquid.

(OR)

(i) Discuss the refraction through a glass-slab and show that the emergent ray is parallel to the incident ray but laterally displaced.

(ii) Write the condition for total internal reflection.

(iii) Redraw the diagram given below and mark the position of the center of curvature of the spherical mirror used in the given set up.



***** ALL THE BEST *****