CENTRE FOR ADVANCEMENT OF STANDARDS IN EXAMINATIONS

(GEMS ASIAN SCHOOLS)

COMMON REHEARSAL EXAMINATIONS 2024

(ALL INDIA SENIOR SCHOOL CERTIFICATE EXAMINATION)

Subject: PHYSICS **Time: 3 hours**

Subject Code: 042 **Max. Marks: 70**

General Instructions:

- There are 33 questions in all. All questions are compulsory.
- This question paper has five sections: Section A, Section B, Section C, Section D, and Section E.
- All the sections are compulsory.
- **Section A** contains sixteen questions, twelve MCQ and four Assertion Reasoning based of one 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.
- 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.
- Use of calculators are not allowed.
- You may use the following values of physical constants wherever necessary.
  - **i.** $c = 3 \times 10^{8}$ m/s
  - **ii.** $h = 6.63 \times 10^{-34}$ Js
  - **iii.** $e = 1.6 \times 10^{-19}$ C
  - **iv.** $\mu_0 = 4\pi \times 10^{-7}$ Tm A^{-1}
  - **v.** $\epsilon_0 = 8.854 \times 10^{-12}$ C^2 N^{-1} m^{-2}
  - **vi.** Mass of electron $= 9.1 \times 10^{-31}$ kg
  - **vii.** Avogadro's number $= 6.023 \times 10^{23}$ per gram mole

SECTION -A

1. When a metallic surface is illuminated with radiation of wavelength λ, the stopping potential is V. If the same surface is illuminated with radiation of wavelength 2λ, the stopping potential is $\frac{V}{4}$. The threshold wavelength for the metallic surface 1

   a) 3 λ b) $\frac{5}{2}\lambda$ c) 4 λ d) 5 λ

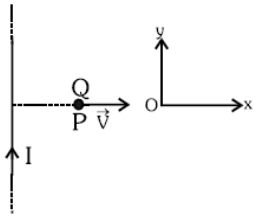
2. A particle having a charge q_1 exerts F electrostatic force on the charge q_2 at rest. If a particle has a charge $\frac{q_1}{4}$ is placed midway between the line joining the two charges q_1 and q_2. Then electrostatic force on q_2 due to q_1 will become/remain 1

   a) 2F b) $\frac{F}{2}$ c) F d)zero

3. An α-particle of energy 5 MeV is scattered through 180° by a fixed uranium nucleus. The distance of the closest approach is of the order of 1

   a) 10^{-10} m b) 10^{-13} m c) 10^{-14} m d) 10^{-16} m

4. A very long straight wire carries a current I. At the instant when a charge +Q at point P has velocity $\vec{v}$, as shown, the force on the charge is:- 1



   a) along Ox b)along Oy c)opposite to Ox d)opposite to Oy

5. There are four lightweight rod samples A, B, C, and D separately suspended by threads. A bar magnet is slowly brought near each sample and the following observations are noted: 1

   i) A is feebly repelled ii)B is feebly attracted

   iii) C is strongly attracted iv)D remains unaffected

Which of the following is true?

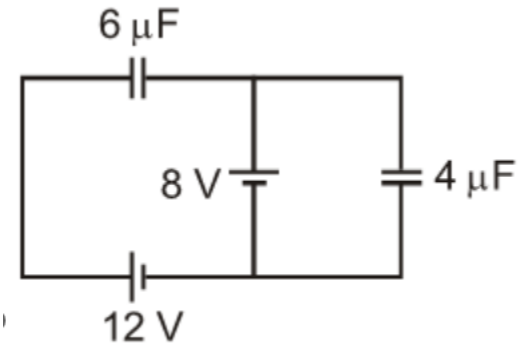
a) C is of a diamagnetic material b) D is of a ferromagnetic material

c) A is of a non-magnetic material d) B is of a paramagnetic material

6. In order to pass 10% of the main current through a moving coil galvanometer of 99 Ω, the resistance of the required shunt is: 1

a) 9 Ω b) 9.9 Ω c) 10 Ω d) 11 Ω

7. In the circuit shown in the figure, energy stored in 6 μF capacitor will be: 1



a) 48 x 10^{-6}J b)32 x 10^{-6}J c)96 x 10^{-6}J d)24 x 10^{-6}J

8. An electron enters uniform electric field maintained by parallel plates and of value 'E' V m^{-1} with a velocity 'v 'ms^{-1}. The plates are separated by a distance 'd' metre. What is the acceleration of the electron in the field? 1

(a) eE/m (b) - eE/m (c) ed/m (d) ed^2/m

9. A transformer is used to light a 100W and 110V lamp from 220V mains. If the main current is 0.5A, the efficiency of the transformer is approximately: 1

a) 90% b)50% c)30% d)10%

10. If E and B denote electric and magnetic fields respectively, which of the following is dimensionless? 1

(a) $\sqrt{(\mu_0\varepsilon_0)}$ E/B (b) $\mu_0\varepsilon_0$ E/B (c) $\mu_0\varepsilon_0$ (B/E)2 (d) $E/\varepsilon_0 \times \mu_0/B$

11. Two circular coils 1 and 2 are made from the same wire but the radius of the 1st coil is twice that of the 2nd coil. What potential difference in volts should be applied across them so that the magnetic field at the centres is the same? 1

a) 2 times of the first coil b)3 times of the first coil

c) 4 times of the first coil d)6 times of the first coil

12. The ratio of the energies of the hydrogen atom in its first to second excited states is 1

a) $\frac{1}{4}$ b) $\frac{4}{9}$ c) $\frac{9}{4}$ d) 4

For Questions 13 - 16, two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the options (a), (b), (c) and (d) 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):** The electrical conductivity of a semiconductor increases on doping. 1

Reason (R): Doping always increases the number of electrons in the semiconductor.

14. **Assertion(A):** In Young's double slit experiment if the wavelength of incident monochromatic light is just doubled, the number of bright fringes on the screen will increase. 1

Reason(R): The maximum number of bright fringes on the screen is directly proportional to the wavelength of light used.

15. **Assertion(A):** If a convex lens is placed in water, its converging power decreases. 1

Reason(R): The focal length of the convex lens relative to water is greater than that relative to air.

16. **Assertion(A):** The resistance of a given mass of copper wire is inversely proportional to the square of length. 1

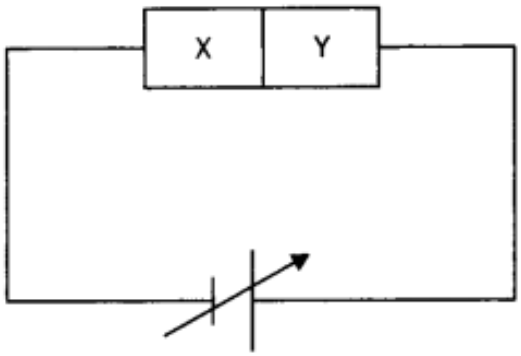
Reason(R): When a copper wire of a given mass is stressed to increase its length, its cross-sectional area also increases.

SECTION-B

17. Two semiconductor materials X and Y, shown in the given figure, are made by doping germanium crystal with indium and arsenic respectively. The two are joined end to end and connected to a battery as shown. 2

    a) Will the junction be forward-biased or reverse-biased?

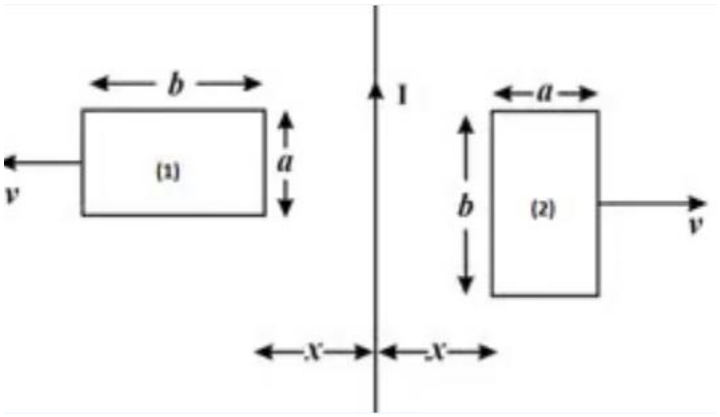
    b) Sketch a V-I graph for this arrangement.



18. a) Red light, however bright it is, cannot produce the emission of electrons from a clean zinc surface,but even weak ultraviolet radiation can do so, why? 2

    b) X-rays of wavelength λ fall on a photosensitive surface,emitting electrons. Assuming that the work function of the surface can be neglected,prove that the de Broglie wavelength of electrons emitted will be $\sqrt{\frac{h\lambda}{2mc}}$.

19. The figure shows two identical rectangular loops (1) and (2), placed on a table along with a straight long current carrying conductor between them. 2



a) What will be the directions of the induced currents in the loops when they are pulled away from the conductor with same velocity v ?

b) Will the emf induced in the two loops be equal ? Justify your answer

20. A cell of emf E and internal resistance r is connected to two external resistances R1 and R2 and a perfect ammeter. The current in the circuit is measured in four different situations: 2
(i) without any external resistance in the circuit.
(ii) with resistance R1 only
(iii) with R1 and R2 in series combination
(iv) with R1 and R2 in parallel combination.
The currents measured in the four cases are 0.42 A, 1.05 A, 1.4 A and 4.2 A, but not necessarily in that order. Identify the currents corresponding to the four cases mentioned above.

21. A figure divided into squares each of size 1mm^2 is being viewed at a distance of 8 cm through a converging lens of focal length 12cm. 2

a) What is the magnification produced by the lens ?

b) How much is the area of each square in the virtual image?

OR

Three immiscible liquids of densities $d_1 > d_2 > d_3$ and refractive indices $\mu_1 > \mu_2 > \mu_3$ are put in a beaker. The height of each liquid column is h/3 . A dot is made at the bottom of the beaker. For near normal vision, find the apparent depth of the dot.

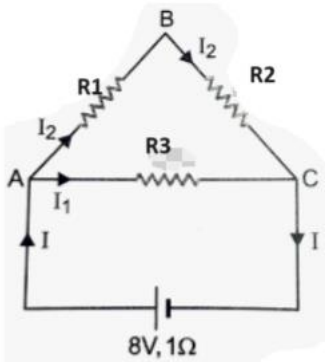
SECTION-C

22. a) What characteristic property of nuclear force explains the constancy of binding energy per nucleon (BE/A) in the range of mass number 'A' lying $30 < A < 170$? 3

b) Show that the density of a nucleus over a wide range of nuclei is constant, independent of mass number.

23. A molecule of a substance has a permanent electric dipole moment of magnitude equal to $10^{-29}\ Cm$. A mole of this substance is polarized (at low temperature) by applying a strong electrostatic field of magnitude (10^6 Vm^{-1}). The direction of the field is suddenly changed by an angle of 60°. Estimate the heat released by the substance in aligning its dipole along the new direction of the field. For simplicity, assume 100% polarisation of sample. 3

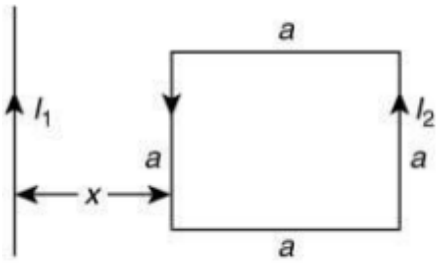
24. The uniform wire of resistance 12 Ω is cut into three pieces so that the ratio of the resistances $R_1 : R_2 : R_3 = 1 : 2 : 3$ and the three pieces are connected to form a triangle across which a cell of emf 8V and internal resistance 1 Ω is connected as shown. Calculate the current through each part of the circuit. 3



25. Using de Broglie's hypothesis, explain with the help of a suitable diagram,Bohr's second postulate of quantisation of energy levels in a hydrogen atom. 3

26. a) Write the expression for the magnetic moment ($\vec{M}$) due to a planar square loop of side 'l' carrying a steady current *I* in a vector form. 3

b) A square loop of side 'a' carrying a current l_2 is kept at a distance x from an infinitely long straight wire carrying a current l_1 as shown in the figure. Obtain the expression for the resultant force acting on the loop.



OR

Two long straight parallel conductors carry steady currents l_1 and l_2 separated by a distance d. If the currents are flowing in the same direction, show how the magnetic field set up in one produces an attractive force on the other. Obtain the expression for this force. Hence define one ampere.

27. (a) Use Huygen's principle to verify the laws of refraction. 3

(b) Draw the diagrams to show the behaviour of plane wavefronts as they
(i) pass through a thin convex lens and
(ii) reflect by a concave mirror.

28. a) Define the term 'self-inductance' of a coil. Write its S.I. unit. 3

b) Show that magnetic energy required to build up the current I in a coil of self-inductance L,is given by $\frac{1}{2}LI^2$.

SECTION -D

Case Study Based Questions

29. **Read the following paragraph and answer the questions that follow.** 4

A **diode** is a two-terminal electronic component that conducts current primarily in one direction (asymmetric conductance). It has low (ideally zero) resistance in one direction, and high (ideally infinite) resistance in the other.

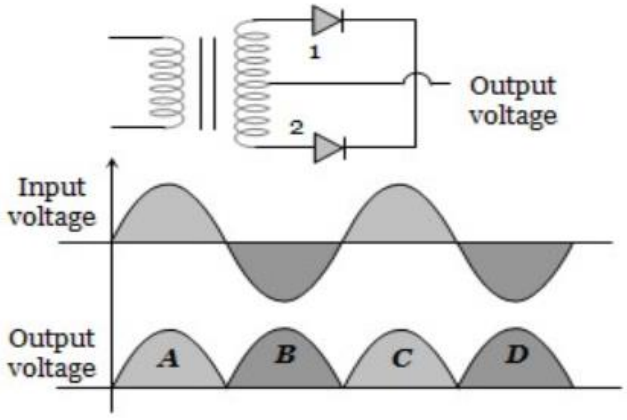
A semiconductor diode, the most commonly used type today, is a crystalline piece of semiconductor material with a p–n junction connected to two electrical terminals. It has an exponential current–voltage characteristic. Semiconductor diodes were the first semiconductor electronic devices. The discovery of asymmetric electrical conduction across the contact between a crystalline mineral and a metal was made by German

physicist Ferdinand Braun in 1874. Today, most diodes are made of silicon, but other semiconducting materials such as gallium arsenide and germanium are also used.

The obsolete *thermionic diode* is a vacuum tube with two electrodes, a heated cathode and a plate, in which electrons can flow in only one direction, from cathode to plate.

Among many uses, diodes are found in rectifiers to convert alternating current (AC) power to direct current (DC), demodulation in radio receivers, and can even be used for logic or as temperature sensors. A common variant of a diode is a light-emitting diode, which is used as electric lighting and status indicators on electronic devices.

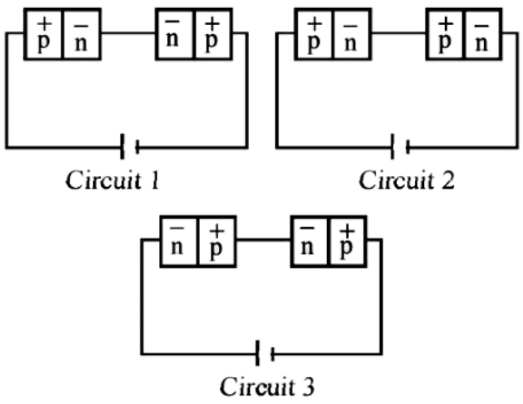
i. A full wave rectifier circuit along with the input and output voltages is shown in the figure



The contribution to output voltage from diode-2 is

a) A,C b)B,D c) B,C d) A,D

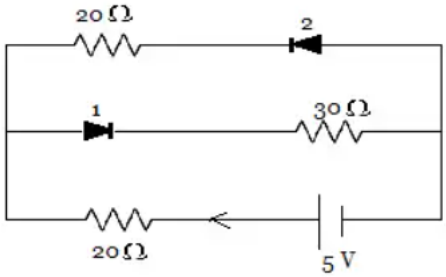
ii. Two identical p-n junction may be connected in series with a battery in three ways as shown in the adjoining figure. The potential drop across the p-n junctions are equal in



a) First and second circuits b)Second and third circuits

c) Third and first circuits d) All of these

iii) Current in the circuit will be



a) 5/40 A b) 5/50A c) 5/10 A d) 5/20A

iv) In half wave rectification, if the input frequency is 60 Hz, then the output frequency would be:

a) 30 Hz b)60 Hz c) 120 Hz d) Zero

OR

The breakdown in a reverse biased p-n junction is more likely to occur due to :

a) Large velocity of the majority charge carriers if the doping concentration is small.

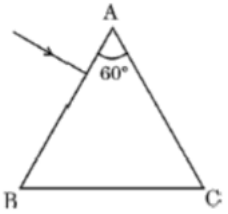
b) Large velocity of the minority charge carriers if the doping concentration is small.

c) Strong electric field in a depletion region if the doping concentration is small.

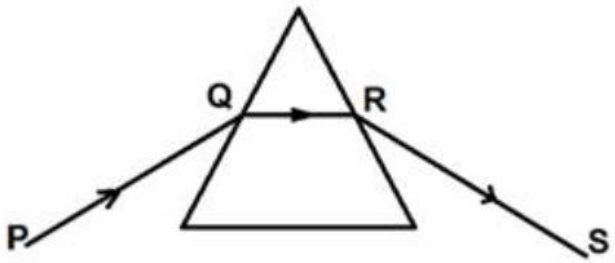
d) Strong electric field in a depletion region if the doping concentration is large

30. **Read the following paragraph and answer the questions that follow**. 4

Strontium titanate is a rare oxide – a natural mineral found in Siberia. It is used as a substitute for diamond because its refractive index and critical angle are 2.41 and 24.5 , respectively, which are approximately equal to the refractive index and critical angle of diamond. It has all the properties of diamond. Even an expert jeweller is unable to differentiate between diamond and strontium titanate. A ray of light is incident normally on one face of an equilateral triangular prism ABC made of strontium titanate.



i. A ray of light is incident on an equilateral glass prism placed on a horizontal table. For minimum deviation, which of the following is true?



a) RS is horizontal b)either PQ or RS is horizontal

c) QR is horizontal d)PQ is horizontal

ii. The refractive index of an equilateral triangular prism kept in air is $\sqrt{2}$. Calculate the angle of minimum deviation

a) 30^0 b)45^0 c)60^0 d) 90^0

iii. For a glass prism, the angle of minimum deviation will be smallest for the light of

a) red colour b)blue colour c) yellow colour d) green colour

iv. A ray of light incident at an angle θ on a refracting face of a prism emerges from the other face normally. If the angle of the prism is 5^o and the prism is made of a material of refractive index 1.5, the angle of incidence is

a) 7.5^o b)5^o c)15^o d) 2.5^o

OR

The refractive index of the material of a prism is $\sqrt{2}$ and the angle of the prism is 30^o.One of the two refracting surfaces of the prism is made a mirror inwards, by silver coating. A beam of monochromatic light entering the prism from the other face will retrace its path (after reflection from the silvered surface) if its angle of incidence of the prism is

a) 60^o b)45^o c) 30^o d) zero

SECTION -E

31. (a) Draw a labelled ray diagram of a compound microscope and write an expression for its magnifying power. 5

(b) The focal length of the objective and eye-lens of a compound microscope are 2 cm and 6.25 cm respectively. The distance between the lenses is 15 cm.

(i) How far from the objective lens, will the object be kept, so as to obtain the final image at the near point of the eye?

(ii) Also calculate its magnifying power.

OR

(a) State the importance of coherent sources in the phenomenon of interference.

(b) In Young's double slit experiment, the two slits 0.12 mm apart are illuminated by monochromatic light of wavelength 420 nm. The screen is 1.0 m away from this slits. Find the distance of the second (a) bright fringe, (b) dark fringe from the central maximum.

(c) Show that the angular width of the first diffraction fringe is half of that of the central fringe.

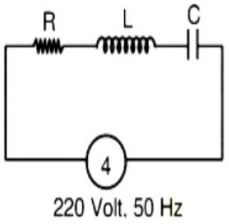
(d) If a monochromatic source of light is replaced by white light, what change would you observe in the diffraction pattern?

32. a) Draw the diagram of a device which is used to decrease high ac voltage into a low ac voltage and state its working principle. Write four sources of energy loss in this device. 5

b) 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 substation in the town. Estimate the line power loss in the form of heat.

OR

A voltage $V=V_0 \sin \omega t$ is applied to a series LCR circuit. Derive the expression for the average power dissipated over a cycle. a) Under what condition is no power dissipated even though the current flows through the circuit. b) In LCR ac circuit $V_L = V_C = 2 V_R$ and $R = 5\ \Omega$, if $L= \frac{1}{K\Pi}$ then find K.



33. a) Derive an expression for the electric field E due to a dipole of length '2a' at a point distant r from the centre of the dipole on the axial line. b) Draw a graph of E versus r for r >>a. 5

c)If this dipole were kept in a uniform external electric field E_0, diagrammatically represent the position of the dipole in stable and unstable equilibrium and write the expressions for the torque acting on the dipole in both cases.

OR

a) Using Gauss's law, prove that the electric field at a point due to a uniformly charged infinite plane sheet is independent of the distance from it.

b) An infinitely large thin plane sheet has a uniform surface charge density +σ. Obtain the expression for the amount of work done in bringing a point charge q from infinity to a point, distant r, in front of the charged plane sheet.

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