

SET ~ 2

Q.P. Code 55/4/2

Candidates must write the Q.P. Code
on the title page of the answer-book. *



PHYSICS (Theory)

Time allowed : 3 hours

Maximum Marks : 70

(i)

Please check that this question paper contains **27** printed pages.

(ii)

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)

Please check that this question paper contains **35** questions.

(iv)

Please write down the serial number of the question in the answer-book before attempting it.

(v)

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 students 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 strictly follow them :

- (i) *This question paper contains **35** questions. **All** questions are **compulsory**.*
- (ii) *This question paper is divided into **five** Sections – **A, B, C, D** and **E**.*
- (iii) *In **Section A** – Questions no. **1** to **18** are Multiple Choice (MCQ) type questions, carrying **1** mark each.*
- (iv) *In **Section B** – Questions no. **19** to **25** are Very Short Answer (VSA) type questions, carrying **2** marks each.*
- (v) *In **Section C** – Questions no. **26** to **30** are Short Answer (SA) type questions, carrying **3** marks each.*
- (vi) *In **Section D** – Questions no. **31** to **33** are Long Answer (LA) type questions carrying **5** marks each.*
- (vii) *In **Section E** – Questions no. **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.*

Use the following values of physical constants, if required :

$$c = 3 \times 10^8 \text{ m/s}$$

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

$$e = 1.6 \times 10^{-19} \text{ C}$$

$$\mu_0 = 4\pi \times 10^{-7} \text{ T m A}^{-1}$$

$$\epsilon_0 = 8.854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$$

$$\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$$

$$\text{Mass of electron (m}_e\text{)} = 9.1 \times 10^{-31} \text{ kg}$$

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

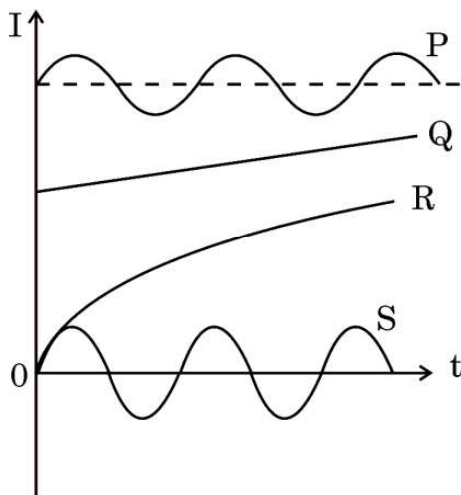
$$\text{Mass of proton} = 1.673 \times 10^{-27} \text{ kg}$$

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

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

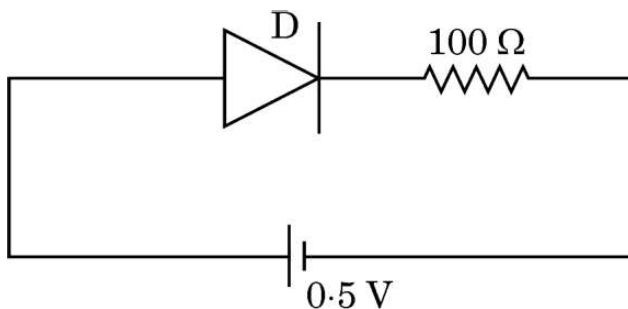
SECTION A

1. The figure shows variation of current (I) with time (t) in four devices P, Q, R and S. The device in which an alternating current flows is :



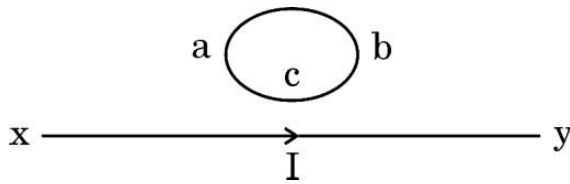
- (a) P (b) Q (c) R (d) S
2. The electromagnetic waves used in radar systems are :
- (a) Infrared waves (b) Ultraviolet rays
(c) Microwaves (d) X-rays
3. In a Young's double-slit experiment, the fringe width is found to be β . If the entire apparatus is immersed in a liquid of refractive index μ , the new fringe width will be :
- (a) β (b) $\mu\beta$ (c) $\frac{\beta}{\mu}$ (d) $\frac{\beta}{\mu^2}$
4. Photons of energy 4.3 eV are incident on a photosensitive surface of work function 2.3 eV. The stopping potential for photoelectrons is :
- (a) 2.0 eV (b) 2.3 eV
(c) 4.3 eV (d) 6.6 eV
5. Which of the following statements is **not** true for nuclear forces ?
- (a) They are stronger than Coulomb forces.
(b) They have about the same magnitude for different pairs of nucleons.
(c) They are always attractive.
(d) They saturate as the separation between two nucleons increases.

6. A point charge q is kept at a distance r from an infinitely long straight wire with charge density λ . The magnitude of the electrostatic force experienced by charge q is :
- (a) Zero (b) $\frac{q\lambda}{2\pi \epsilon_0 r}$
- (c) $\frac{q\lambda}{4\pi \epsilon_0 r}$ (d) $\frac{q\lambda}{\epsilon_0 r}$
7. The ratio of the magnitude of magnetic moment to that of angular momentum, of an electron revolving around the nucleus in a hydrogen atom is :
- (a) Zero (b) $9.27 \times 10^{-24} \text{ C/kg}$
- (c) $8.8 \times 10^{10} \text{ C/kg}$ (d) $6.6 \times 10^{-12} \text{ C/kg}$
8. Which one of the following has negative value of susceptibility ?
- (a) Nickel (b) Aluminium
- (c) Lead (d) Iron
9. The difference in mass of ${}^7\text{X}$ nucleus and total mass of its constituent nucleons is 21.00 u. The binding energy per nucleon for this nucleus is equal to the energy equivalent of :
- (a) 3 u (b) 3.5 u (c) 7 u (d) 21 u
10. The threshold voltage for a p-n junction diode used in the circuit is 0.7 V. The type of biasing and current in the circuit are :



- (a) Forward biasing, 0 A (b) Reverse biasing, 0 A
- (c) Forward biasing, 5 mA (d) Reverse biasing, 2 mA

11. The direction of induced current in the loop abc is :



- (a) along abc if I decreases
(b) along acb if I increases
(c) along abc if I is constant
(d) along abc if I increases
12. An ac voltage $v = v_0 \sin \omega t$ is applied to a series combination of a resistor R and an element X. The instantaneous current in the circuit is $I = I_0 \sin (\omega t + \frac{\pi}{4})$. Then which of the following is correct ?
- (a) X is a capacitor and $X_C = \sqrt{2} R$
(b) X is an inductor and $X_L = R$
(c) X is an inductor and $X_L = \sqrt{2} R$
(d) X is a capacitor and $X_C = R$
13. A plane wavefront is incident on a concave mirror of radius of curvature R. The radius of the refracted wavefront will be :
- (a) $2R$ (b) R (c) $\frac{R}{2}$ (d) $\frac{R}{4}$
14. A proton and an alpha particle have the same kinetic energy. The ratio of de Broglie wavelengths associated with the proton to that with the alpha particle is :
- (a) 1 (b) 2 (c) $2\sqrt{2}$ (d) $\frac{1}{2}$
15. The potential energy of an electron in the second excited state in hydrogen atom is :
- (a) -3.4 eV (b) -3.02 eV (c) -1.51 eV (d) -6.8 eV

Questions number **16** to **18** are Assertion (A) and Reason (R) type questions. Two statements are given — one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer from the codes (a), (b), (c) and (d) as given below.

- (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).
- (b) Both Assertion (A) and Reason (R) are true, but Reason (R) is **not** the correct explanation of the Assertion (A).
- (c) Assertion (A) is true, but Reason (R) is false.
- (d) Assertion (A) is false and Reason (R) is also false.

- 16.** *Assertion (A) :* A current carrying square loop made of a wire of length L is placed in a magnetic field. It experiences a torque which is greater than the torque on a circular loop made of the same wire carrying the same current in the same magnetic field.

Reason (R) : A square loop occupies more area than a circular loop, both made of wire of the same length.

- 17.** *Assertion (A) :* In 'n' type semiconductor, number density of electrons is greater than the number density of holes but the crystal maintains an overall charge neutrality.

Reason (R) : The charge of electrons donated by donor atoms is just equal and opposite to that of the ionised donor.

- 18.** *Assertion (A) :* When three electric bulbs of power 200 W, 100 W and 50 W are connected in series to a source, the power consumed by the 50 W bulb is maximum.

Reason (R) : In a series circuit, current is the same through each bulb, but the potential difference across each bulb is different.

SECTION B

- 19.** (a) Obtain an expression for electrostatic potential energy of a system of three charges q , $2q$ and $-3q$ placed at the vertices of an equilateral triangle of side a .

OR

- (b) Two small conducting balls A and B of radius r_1 and r_2 have charges q_1 and q_2 respectively. They are connected by a wire. Obtain the expression for charges on A and B, in equilibrium. 2

20. Answer the following giving reasons : 2

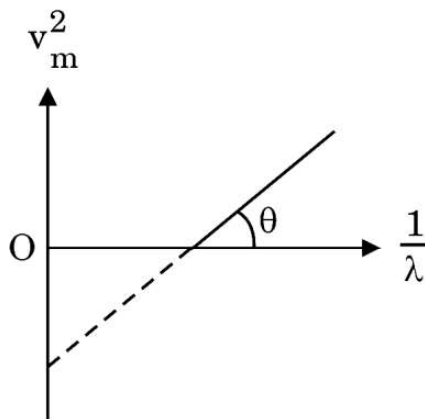
- (a) Do the magnetic field lines also represent the 'lines of force' on a moving charged particle at every point ?
- (b) If magnetic monopoles existed, how would the Gauss's law of magnetism be modified ?

21. (a) What is a displacement current ? How is it different from a conduction current ? 2

OR

- (b) Write any two characteristics of an electromagnetic wave. Why are microwaves used in radar systems ? 2

22. The figure shows v_m^2 versus $\frac{1}{\lambda}$ graph for photoelectrons emitted from a surface where v_m is the maximum speed of electrons and λ is the wavelength of incident radiation. Using this graph and Einstein's photoelectric equation, obtain the expression for Planck's constant and work function of the surface. 2



23. Show that the density of a nucleus is independent of its mass number. Why are lighter nuclei more stable than heavier nuclei ? 2

- 24.** Use Gauss's law to obtain the expression for electric field due to a uniformly charged infinite plane thin sheet. 2
- 25.** Two identical cells, each of emf E and internal resistance r , are connected with a load resistance R , first in series and then in parallel. Obtain the condition under which the current through R is same in both cases. 2

SECTION C

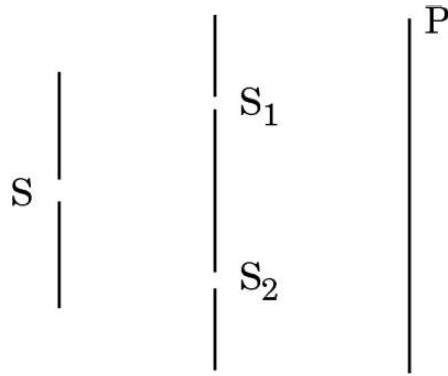
- 26.** (a) A resistor of $30\ \Omega$ and a capacitor of $\frac{250}{\pi}\ \mu\text{F}$ are connected in series to a $200\ \text{V}$, $50\ \text{Hz}$ ac source. Calculate (i) the current in the circuit, and (ii) voltage drops across the resistor and the capacitor. (iii) Is the algebraic sum of these voltages more than the source voltage ? If yes, solve the paradox. 3

OR

- (b) A series LCR circuit with $R = 20\ \Omega$, $L = 2\ \text{H}$ and $C = 50\ \mu\text{F}$ is connected to a $200\ \text{volts}$ ac source of variable frequency. What is (i) the amplitude of the current, and (ii) the average power transferred to the circuit in one complete cycle, at resonance ? (iii) Calculate the potential drop across the capacitor. 3
- 27.** (a) (i) In diffraction due to a single slit, the phase difference between light waves reaching a point on the screen is 5π . Explain whether a bright or a dark fringe will be formed at the point.
- (ii) What should the width (a) of each slit be to obtain eight maxima of two double-slit patterns (slit separation d) within the central maximum of the single slit pattern ?
- (iii) Draw the plot of intensity distribution in a diffraction pattern due to a single slit. 3

OR

- (b) (i) In a Young's double-slit experiment $SS_2 - SS_1 = \frac{\lambda}{4}$, where S_1 and S_2 are the two slits as shown in the figure. Find the path difference $(S_2P - S_1P)$ for constructive and destructive interference at P.



- (ii) What is the effect on the interference fringes in a Young's double-slit experiment, if the monochromatic source S is replaced by a source of white light ?

3

28. (a) Differentiate between 'impact parameter' and 'distance of closest approach' in alpha particle scattering experiment. Identify, situations when impact parameter is (i) minimum, and (ii) very large.
- (b) An electron cannot revolve around the nucleus in a hydrogen atom at an arbitrary distance. Explain.

3

29. Two infinitely long parallel conductors A and B, separated by 2 cm, carry 6 A and 2 A currents in opposite directions respectively. Find :

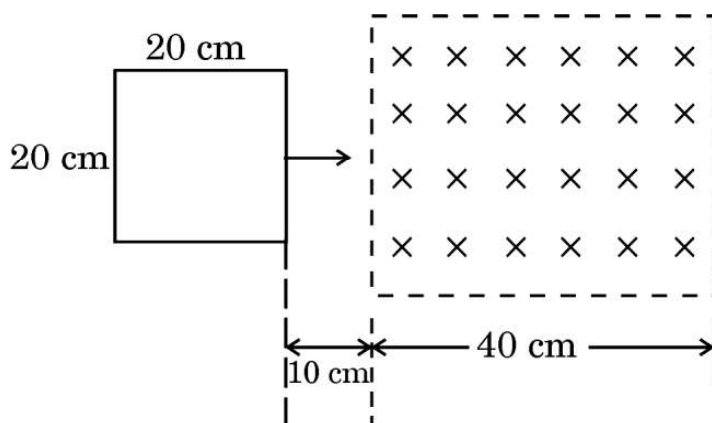
- (a) the net magnetic field at a point midway between A and B.
- (b) the force acting per unit length on B.

3

30. (a) Two coplanar concentric circular loops of radii R and r ($\ll R$) are arranged coaxially. Obtain the expression for their mutual inductance.

- (b) A square loop of side 20 cm starts moving at $t = 0$ with a velocity of 5 cm/s towards a region of uniform magnetic field as shown in the figure. Specify the time interval(s) during which induced emf is produced in the loop.

3



SECTION D

31. (a) (i) Draw a ray diagram to show how the final image is formed at infinity in an astronomical refracting telescope. Obtain an expression for its magnifying power.
- (ii) Two thin lenses L_1 and L_2 , L_1 being a convex lens of focal length 24 cm and L_2 a concave lens of focal length 18 cm are placed coaxially at a separation of 45 cm. A 1 cm tall object is placed in front of the lens L_1 at a distance of 36 cm. Find the location and height of the image formed by the combination.

5

OR

- (b) (i) Explain the working principle of an optical fibre with the help of a diagram. Mention one use of a light pipe.
- (ii) A ray of light is incident at an angle of 60° on one face of a prism with the prism angle $A = 60^\circ$. The ray passes symmetrically through the prism. Find the angle of minimum deviation (δ_m) and refractive index of the material of the prism. If the prism is immersed in water, how will δ_m be affected? Justify your answer.

5

- 32.** (a) (i) A germanium crystal is doped with antimony. With the help of energy-band diagram, explain how the conductivity of the doped crystal is affected.
- (ii) Briefly explain the two processes involved in the formation of a p-n junction.
- (iii) What will the effect of (1) forward biasing, and (2) reverse biasing be on the width of depletion layer in a p-n junction diode ?

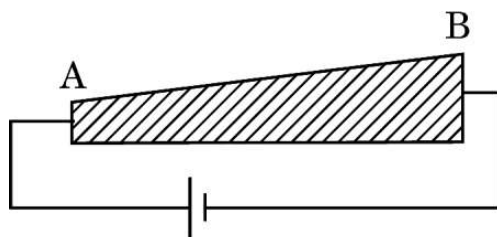
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OR

- (b) (i) With the help of a circuit diagram, briefly explain the working of a full-wave rectifier using p-n junction diodes.
- (ii) Draw $V - I$ characteristics of a p-n junction diode. Explain how these characteristics make a diode suitable for rectification.
- (iii) Carbon and silicon have the same lattice structure. Then why is carbon an insulator but silicon a semiconductor ?

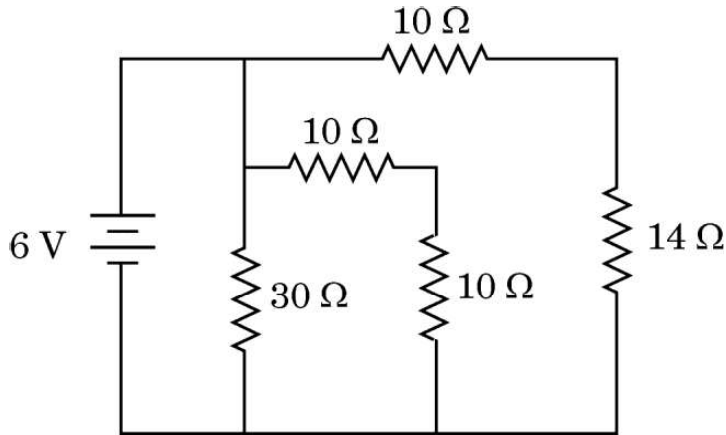
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- 33.** (a) (i) Define mobility of electrons. Give its SI units.
- (ii) A steady current flows through a wire AB, as shown in the figure. What happens to the electric field and the drift velocity along the wire ? Justify your answer.



- (iii) आरेख में दर्शाए गए परिपथ पर विचार कीजिए । परिपथ का प्रभावी प्रतिरोध और बैटरी से ली गई विद्युत धारा ज्ञात कीजिए ।

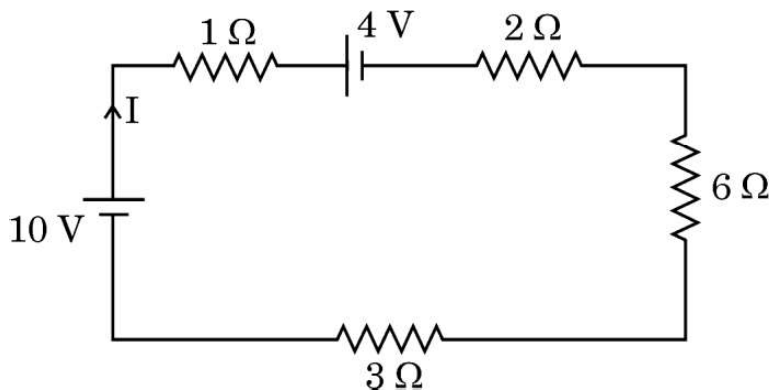
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अथवा

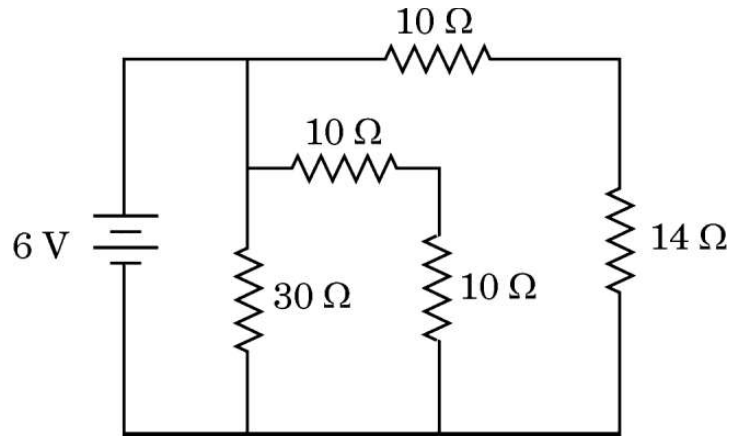
- (ख) (i) किसी तार की वैद्युत चालकता की परिभाषा दीजिए और इसका SI मात्रक लिखिए ।
- (ii) (1) किसी निम्न-वोल्टता की बैटरी, और (2) किसी उच्च-वोल्टता की बैटरी से निरापद रूप से उच्च धारा ली जानी है । दोनों बैटरियों के आन्तरिक प्रतिरोधों के विषय में आप क्या कह सकते हैं ?
- (iii) आरेख में दर्शाए गए परिपथ में बैटरियों द्वारा एक मिनट में परिपथ को आपूर्त की जाने वाली कुल ऊर्जा परिकलित कीजिए ।

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- (iii) Consider the circuit shown in the figure. Find the effective resistance of the circuit and the current drawn from the battery.

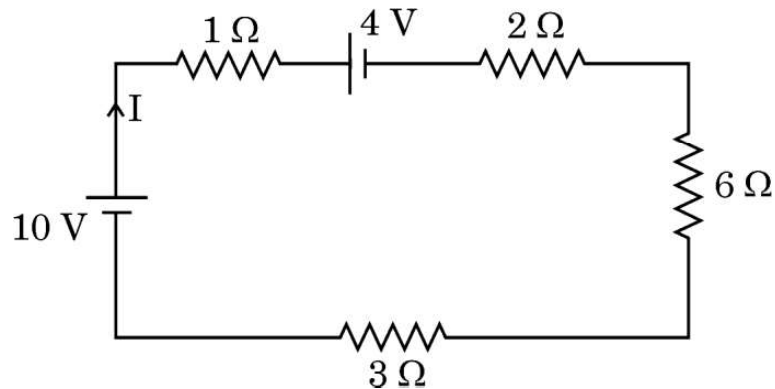
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OR

- (b) (i) Define electrical conductivity of a wire. Give its SI unit.
- (ii) High current is to be drawn safely from (1) a low-voltage battery, and (2) a high-voltage battery. What can you say about the internal resistance of the two batteries ?
- (iii) Calculate the total energy supplied by the batteries to the circuit shown in the figure, in one minute.

5



खण्ड ड

34. लेंस मेकर सूत्र उपयुक्त वक्रता त्रिज्या के पृष्ठों के उपयोग द्वारा वांछित फोकस दूरियों के लेंसों की अभिकल्पना में उपयोगी है। लेंसों की फोकस दूरी लेंस के पदार्थ और उसके प्रतिवेश के माध्यम के अपवर्तनांकों पर भी निर्भर करती है। अपवर्तनांक उपयोग किए जाने वाले प्रकाश के तरंगदैर्घ्य पर निर्भर करता है। किसी लेंस की क्षमता उसकी फोकस दूरी से संबंधित है।

उपर्युक्त के आधार पर निम्नलिखित प्रश्नों के उत्तर दीजिए :

- (क) प्रकाश के तरंगदैर्घ्य में वृद्धि होने पर लेंस की क्षमता किस प्रकार प्रभावित होती है ? 1
- (ख) किसी उत्तल लेंस के दोनों पृष्ठों की वक्रता त्रिज्या R है। इस लेंस के पदार्थ के μ के किस मान के लिए उसकी फोकस दूरी R के बराबर हो जाएगी ? 1
- (ग) वायु में $\mu = 1.5$ के किसी अवतल लेंस की फोकस दूरी 20 cm है। इस लेंस को $\mu = \frac{4}{3}$ के पानी में पूरा डुबो दिया गया है। पानी में इस लेंस की फोकस दूरी परिकलित कीजिए। 2

अथवा

- (ग) कोई बिम्ब किसी लेंस के सामने रखा है जो उसका सीधा प्रतिबिम्ब बनाता है जिसका आवर्धन 3 है। इस लेंस की क्षमता 5 D है। लेंस से बिम्ब और प्रतिबिम्ब की दूरी परिकलित कीजिए। 2

35. स्थिर-वैद्युतिकी स्थिर आवेशों से उत्पन्न बलों, क्षेत्रों और विभवों के अध्ययन से संबंध रखती है। किसी बिन्दु आवेश के कारण बलों और विद्युत क्षेत्रों का मूल रूप से निर्धारण कूलॉम नियम द्वारा होता है। सममित आवेश विन्यासों के विद्युत क्षेत्र को ज्ञात करने में गाउस नियम, जो वास्तव में कूलॉम नियम पर ही आधारित है, हमारी सहायता करता है। कोई आवेश/आवेशों का निकाय जैसे द्विध्रुव किसी विद्युत क्षेत्र में रखे जाने पर किसी बल/बल-आघूर्ण का अनुभव करता है। किसी विद्युत क्षेत्र के सापेक्ष किसी द्विध्रुव को कोई विशिष्ट दिक्विन्यास प्रदान करने के लिए कार्य करने की आवश्यकता होती है।

SECTION E

- 34.** The lens maker's formula is useful to design lenses of desired focal lengths using surfaces of suitable radii of curvature. The focal length also depends on the refractive index of the material of the lens and the surrounding medium. The refractive index depends on the wavelength of the light used. The power of a lens is related to its focal length.

Answer the following questions based on the above :

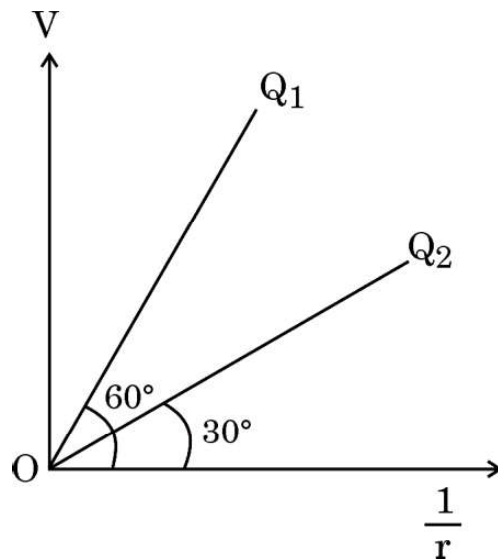
- (a) How will the power of a lens be affected with an increase of wavelength of light ? 1
- (b) The radius of curvature of two surfaces of a convex lens is R each. For what value of μ of its material will its focal length become equal to R ? 1
- (c) The focal length of a concave lens of $\mu = 1.5$ is 20 cm in air. It is completely immersed in water of $\mu = \frac{4}{3}$. Calculate its focal length in water. 2

OR

- (c) An object is placed in front of a lens which forms its erect image of magnification 3. The power of the lens is 5 D. Calculate the distance of the object and the image from the lens. 2
- 35.** Electrostatics deals with the study of forces, fields and potentials arising from static charges. Force and electric field, due to a point charge is basically determined by Coulomb's law. For symmetric charge configurations, Gauss's law, which is also based on Coulomb's law, helps us to find the electric field. A charge/a system of charges like a dipole experience a force/torque in an electric field. Work is required to be done to provide a specific orientation to a dipole with respect to an electric field.

Answer the following questions based on the above :

- (a) Consider a uniformly charged thin conducting shell of radius R . Plot a graph showing the variation of $|\vec{E}|$ with distance r from the centre, for points $0 \leq r \leq 3R$. 1
- (b) The figure shows the variation of potential V with $\frac{1}{r}$ for two point charges Q_1 and Q_2 , where V is the potential at a distance r due to a point charge. Find $\frac{Q_1}{Q_2}$. 1



- (c) An electric dipole of dipole moment of 6×10^{-7} C-m is kept in a uniform electric field of 10^4 N/C such that the dipole moment and the electric field are parallel. Calculate the potential energy of the dipole. 2

OR

- (c) An electric dipole of dipole moment $\vec{p}$ is initially kept in a uniform electric field $\vec{E}$ such that $\vec{p}$ is perpendicular to $\vec{E}$. Find the amount of work done in rotating the dipole to a position at which $\vec{p}$ becomes antiparallel to $\vec{E}$. 2