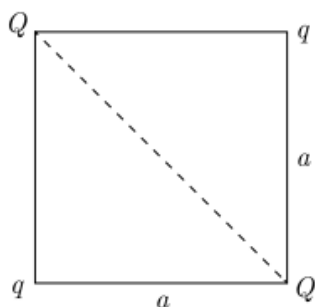


**Instructions to the Students**

- Write only question numbers clearly outside the margin (1, 2, 3.i, 5.b, 4.c.ii, etc.).
- Do not write questions or any titles. (For ex. - Do not write **II. Answer the following**).
- After every answer, give a one-line space.
- For Multiple choice Questions - Both Option and Answer should be written.
- Bullet points & Sub-points should be written inside the margin.
- Do not fold / staple the paper.

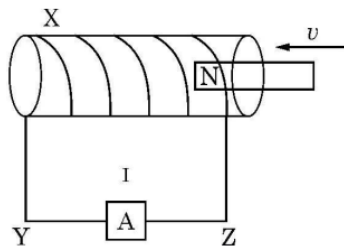
**Section A**

1. In the figure, if net force on Q is zero then value of  $\frac{Q}{q}$  is: [ 1 ]

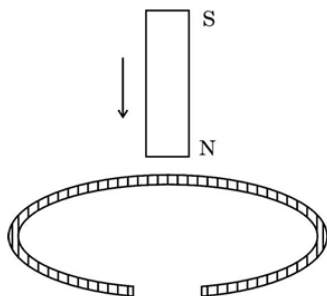


- a)  $\sqrt{2}$                       b)  $2\sqrt{2}$                       c)  $\frac{1}{2\sqrt{2}}$                       d)  $\frac{1}{\sqrt{2}}$
2. In Wheatstone's bridge  $P = 9\ \Omega$ ,  $Q = 11\ \Omega$ ,  $R = 4\ \Omega$  and  $S = 6\ \Omega$ . How much resistance must be put in parallel to the resistance S to balance the bridge? [ 1 ]
- a)  $24\ \Omega$                       b)  $28\ \Omega$                       c)  $26.4\ \Omega$                       d)  $24.6\ \Omega$
3. An inductor, a capacitor and a resistor are connected in series across an AC source of voltage. If the frequency of the source is decreased gradually, the reactance of : [ 1 ]
- a) both the inductor and the capacitor decreases.  
b) inductor decreases and the capacitor increases.  
c) both the inductor and the capacitor increases.  
d) inductor increases and the capacitor decreases.
4. To dissociate an oxygen molecule into two oxygen atoms 5eV of energy is required. The minimum frequency of the appropriate electromagnetic radiation to achieve the dissociation lies in [ 1 ]
- a) visible region.                      b) infrared region.  
c) ultraviolet region.                      d) microwave region.

5. A compound microscope has an objective lens of focal length 1.5 cm and an eyepiece of focal length 5cm. The objective forms a real image 15cm from it. If the final image is formed at the near point (25 cm), what is the magnifying power of the microscope? [ 1 ]  
 a) 40                      b) 50                      c) 54                      d) 60
6. A light source of wavelength  $\lambda$  illuminates a metal surface, and electrons are ejected with a maximum kinetic energy of 2 eV. If the same surface is illuminated by a light source of wavelength  $\lambda/2$ , then the maximum kinetic energy of ejected electrons will be (The work function of the metal is 1 eV). [ 1 ]  
 a) 6 eV                      b) 5 eV                      c) 2 eV                      d) 3 eV
7. Which of the following statements is correct for alpha particle scattering experiment? [ 1 ]  
 a) For angle of scattering  $\theta \approx 0$ , the impact parameter is small.  
 b) For angle of scattering  $\theta \approx \pi$ , the impact parameter is large.  
 c) The number of alpha particles undergoing head-on collision is small.  
 d) The experiment provides an estimate of the upper limit to the size of target atom.
8. In the figure X is a coil wound over a hollow wooden pipe. [ 1 ]

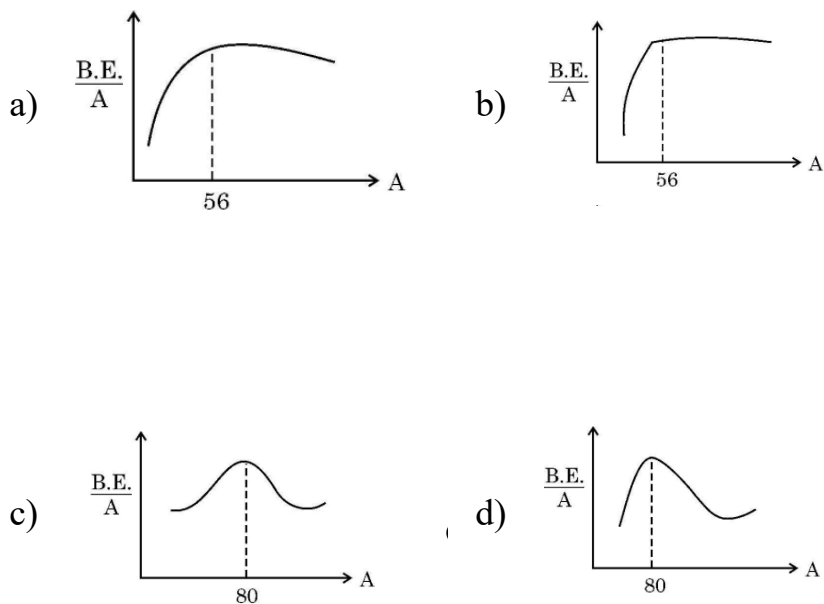


- A permanent magnet is pushed at a constant speed  $v$  from the right into the pipe and it comes out at the left end of the pipe. During the entry and the exit of the magnet, the current in the wire YZ will be from
- a) Y to Z and then Y to Z                      b) Y to Z and then Z to Y  
 c) Z to Y and then Y to Z                      d) Z to Y and then Z to Y
9. A vertically held bar magnet is dropped along the axis of a copper ring having a cut as shown in the diagram. The acceleration of the falling magnet is : [ 1 ]



- a) zero                      b) less than  $g$                       c)  $g$                       d) greater than  $g$
10. In an experiment, 200 V AC is applied at the ends of an LCR-circuit. The circuit consists of an inductive reactance of  $50 \Omega$ , capacitive reactance of  $35 \Omega$  and ohmic resistance of  $20 \Omega$ . The impedance of the circuit is [ 1 ]  
 a)  $15 \Omega$                       b)  $25 \Omega$                       c)  $35 \Omega$                       d)  $45 \Omega$

11. Which of the following figures correctly represent the shape of the curve of binding energy per nucleon as a function of mass number? [ 1 ]



12. A bar magnet having a magnetic moment of  $2 \times 10^4 \text{ JT}^{-1}$  is free to rotate in a horizontal plane. A horizontal magnetic field  $6 \times 10^{-4} \text{ T}$  exists in the space. The work done in taking the magnet slowly from a direction parallel to the field to a direction  $60^\circ$  from the field is [ 1 ]
- a) 12 J                      b) 6 J                      c) 2 J                      d) 0.6 J

13. **Assertion (A):** The ionization energy of an atom is the energy required to remove an electron from the atom in its ground state. [ 1 ]

**Reason (R):** Ionization energy is a measure of the binding energy of the protons in the ground state.

- a) Both (A) and (R) are true and (R) is the correct explanation of (A)  
 b) Both (A) and (R) are true but (R) is not the correct explanation of (A)  
 c) (A) is correct but (R) is wrong  
 d) (A) is wrong but (R) is correct

14. **Assertion(A) :** A convex lens may be diverging. [ 1 ]

**Reason (R) :** The nature of a lens depends upon the refractive indices of the material of lens and surrounding medium besides its geometry.

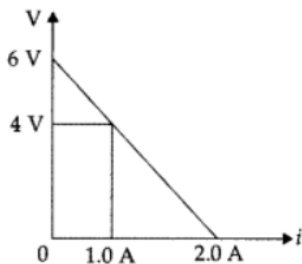
- a) Both (A) and (R) are true and (R) is the correct explanation of (A)  
 b) Both (A) and (R) are true but (R) is not the correct explanation of (A)  
 c) (A) is correct but (R) is wrong  
 d) (A) is wrong but (R) is correct

15. **Assertion (A) :** Thin films such as soap bubble or thin layer of oil spread on water show beautiful colors when illuminated by white light. [ 1 ]
- Reason (R):** It is due to interference of Sun's light reflected from upper and lower surfaces of the film.
- Both (A) and (R) are true and (R) is the correct explanation of (A)
  - Both (A) and (R) are true but (R) is not the correct explanation of (A)
  - (A) is correct but (R) is wrong
  - (A) is wrong but (R) is correct

16. **Assertion (A):** The electric flux through a closed surface depends only on the charge enclosed by the surface. [ 1 ]
- Reason (R):** According to Gauss's law, total flux through a closed surface is independent of the shape or size of the surface.
- Both (A) and (R) are true and (R) is the correct explanation of (A)
  - Both (A) and (R) are true but (R) is not the correct explanation of (A)
  - (A) is correct but (R) is wrong
  - (A) is wrong but (R) is correct

### Section B

17. An electromagnetic wave  $Y_1$ , has a wavelength of 1 cm while another electromagnetic wave  $Y_2$  has a frequency of  $10^{15}$  Hz. Name these two types of waves and write one useful application for each. [ 2 ]
18. The figure shows a plot of terminal voltage 'V' versus the current 'i' of a given cell. Calculate from the graph [ 2 ]
- emf of the cell and
  - internal resistance of the cell

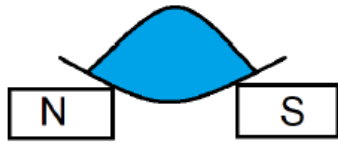


19. A uniform electric field is represented as  $\vec{E} = (3 \times 10^3 \text{ N/C}) \hat{i}$ . Find the electric flux of this field through a square of side 10 cm when the : [ 2 ]
- plane of the square is parallel to y-z plane, and
  - the normal to plane of the square makes an angle of  $60^\circ$  with the x-axis.
- 20.I. A long solenoid has a magnetic field of 0.25 T inside it. If a bar of magnetic susceptibility 5 is inserted into it what will be the magnetic flux density inside it? [ 2 ]

(OR)

20.II. A paramagnetic sample is placed on a watch glass as shown below.

[ 2 ]



Draw diagram to show how the distribution of sample is affected in due course of time. In which case it attains new arrangement quicker

- (i) a hotter sample
- (ii) a colder sample

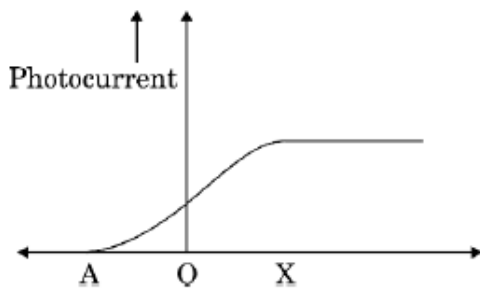
21.I. In the Rutherford's scattering experiment the distance of closest approach for an  $\alpha$  -particle is  $d_0$ . If  $\alpha$  -particle is replaced by a proton, how much kinetic energy in comparison to  $\alpha$  particle will it require to have the same distance of closest approach  $d_0$ ?

[ 2 ]

(OR)

21.II. The following graph shows the variation of photocurrent for a photosensitive metal:

[ 2 ]

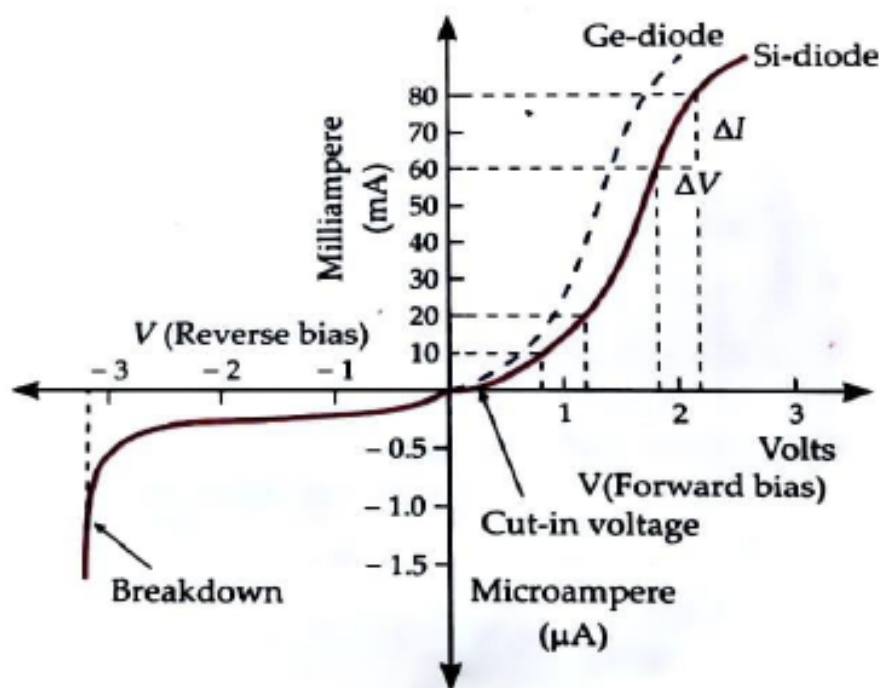


- a) Identify the variable X and A on the horizontal axis.
- b) Draw this graph for three different values of frequencies of incident radiation  $\nu_1, \nu_2$  and  $\nu_3$  ( $\nu_1 > \nu_2 > \nu_3$ ) for same intensity

## Section C

22. The V-I characteristic of a silicon diode is given in fig. below.

[ 3 ]



Calculate the diode resistance in :

- forward bias at  $V=+2$  V and  $V=+1$  V, and
- reverse bias  $V= -1$  V and  $-2$  V.

23. A conductor of length  $l$  is connected to a DC source of potential  $V$ . If the length of the conductor is tripled by gradually stretching it, keeping  $V$  constant, how will
- drift speed of electrons and
  - resistance of the conductor be affected? Justify your answer

[ 3 ]

24. Calculate binding energy per nucleon of  $^{209}_{83}\text{Bi}$  nucleus.

[ 3 ]

Given that mass of  $^{209}_{83}\text{Bi} = 208.980388$  u,

mass of proton =  $1.007825$ u,

mass of neutron =  $1.008665$ u . (given:  $1$  u =  $931$  MeV)

25. A spherical refracting surface with radius of curvature  $R=+20$ cm separates glass ( $n_1=1.50$ ) from air ( $n_2=1.00$ ). An object is located  $30$ cm inside the glass, measured from the vertex of the surface.

[ 3 ]

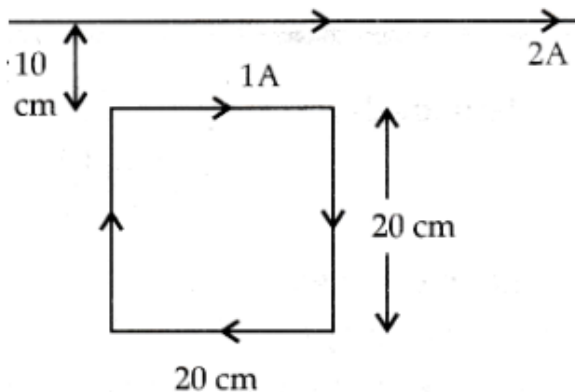
Using the refraction formula for a spherical surface, determine:

- The position of the image formed (give the sign, medium, and nature of the image).
- The linear magnification produced.

26. Give reasons for the following : [ 3 ]

- (1) Why is an objective lens of large focal length and large aperture used in a telescope?
- (2) Two sodium lamps (independent) cannot emit coherent lights.
- (3) The resultant intensity at any point on the screen varies between zero and four times the intensity, due to one slit, in Young's double slit experiment.

27.I. A square loop of side 20 cm carrying current of 1 A is kept near an infinite long straight wire carrying a current of 2 A in the same plane as shown in the figure. [ 3 ]



Calculate the magnitude and direction of the net force exerted on the loop due to the current carrying conductor.

(OR)

27.II. A bar magnet of magnetic moment  $2.5 \text{ JT}^{-1}$  lies aligned with the direction of a uniform magnetic field of  $0.32 \text{ T}$ . [ 3 ]

(a) Find the amount of work done to turn the magnet so as to align its magnetic moment

- (i) normal to the field direction, and
- (ii) opposite to the field direction.

(b) What is the torque on the magnet in above cases (i) and (ii) ?

28. A resistance of  $20 \Omega$ , a capacitance of  $80 \text{ mF}$  and an inductor of  $50 \text{ mH}$  are connected in series. This combination is connected across a  $220 \text{ V}$  ac supply of variable frequency. When the frequency of supply equals the natural frequency of the circuit, calculate : [ 3 ]

- (1) angular frequency of supply
- (2) impedance of the circuit

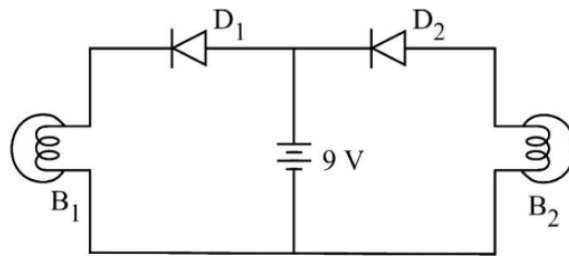
### Section D

29. The process of converting ac into dc is called rectification and the device used is called a rectifier. When ac signal is fed to a junction diode during positive half cycle, the diode is forward biased and current flows through it. During the negative half cycle, the diode is reverse biased and it does not conduct. Thus the

ac signal is rectified. The p-n junction diodes can be used as half-wave and full-wave rectifiers.

29.I. Which bulb/bulbs will glow in the given circuit ?

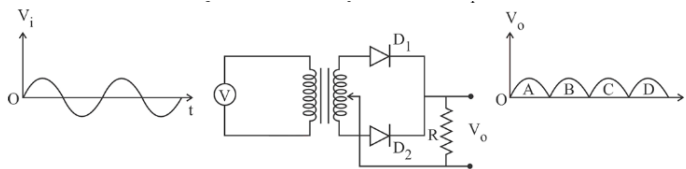
[ 1 ]



- a) B1 only      b) B2 only      c) Both B1 and B2      d) Neither B1 nor B2

29.II. A full-wave rectifier circuit is shown in the figure. The contribution in output waveform from junction diode  $D_1$  is :

[ 1 ]



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

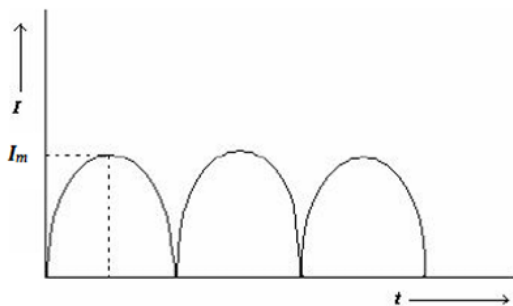
29.III. The output in a half-wave rectifier is :

[ 1 ]

- a) unidirectional without ripple      b) steady and continuous  
c) unidirectional with ripple      d) steady but discontinuous

29.IV. The output current  $I$  versus time ( $t$ ) curve of a full wave rectifier is shown in the figure. The average value of the output current in this case is

[ 1 ]



- a)  $I_m$       b) Zero      c)  $\frac{2I_m}{\pi}$       d)  $\frac{I_m}{\pi}$

30. The photoelectric effect demonstrates the particle nature of light by showing that electrons are emitted from a metal surface only when the incident photons possess sufficient energy. The emission rate depends on how many photons arrive each second, whereas the energy carried by each emitted electron depends solely on the frequency of the incident radiation. When higher-frequency photons strike the surface, the electrons gain more kinetic energy after overcoming the work function of the material. However, even very intense low-frequency radiation fails to eject electrons if the photon energy is below this threshold. The stopping



potential necessary to halt the most energetic electrons increases with frequency, reflecting the direct proportionality between photon energy and frequency. Different metals require different minimum photon energies, but the relationship between stopping potential and frequency remains linear for all because it originates from fundamental constants.

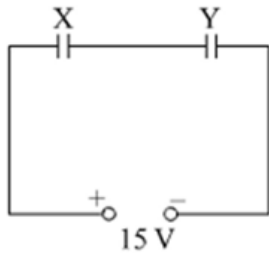
30.I. How does the threshold frequency phenomenon support the particle nature of light? [ 1 ]

30.II. Light of frequency  $7.0 \times 10^{14}$  Hz is incident on a metal surface whose work function is 2.0 eV. Calculate the the energy of the incident photon [ 1 ]

30.III. A metal surface is illuminated with two different light sources, both producing the same photoelectric current, but one has higher frequency than the other. Explain how this is possible, and compare the energies of the emitted electrons in both cases. [ 2 ]

### Section E

31.I. Two parallel plate capacitors X and Y have the same area of plates and same separation between them. X has air between the plates while Y contains a dielectric of  $\epsilon_r = 4$ . [ 5 ]



(i) Calculate capacitance of each capacitor if equivalent capacitance of the combination is  $4 \mu\text{F}$ .

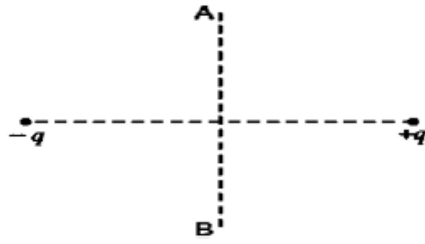
(ii) Calculate the potential difference between the plates of X and Y.

(iii) Estimate the ratio of electrostatic energy stored in X and Y.

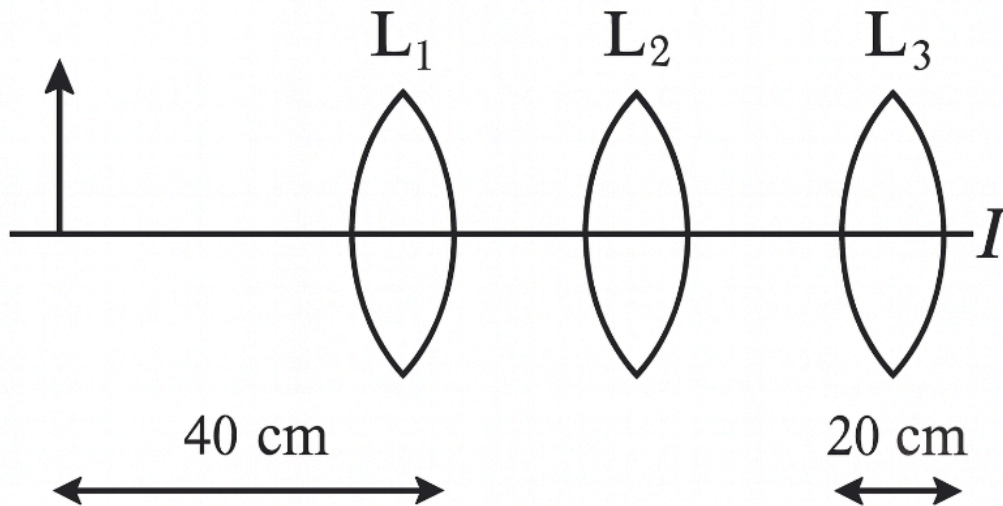
**(OR)**

31.II.i. Two uniformly large parallel thin plates having charge densities  $+\sigma$  and  $-\sigma$  are kept in the X-Z plane at a distance 'd' apart. Sketch an equipotential surface due to electric field between the plates. If a particle of mass m and charge ' $-q$ ' remains stationary between the plates, what is the magnitude and direction of this field? [ 3 ]

- 31.II.ii. A charge 'q' is moved from a point A above a dipole of dipole moment 'p' to a point B below the dipole in equatorial plane without acceleration. Find the work done in the process. [ 2 ]



- 32.I.i. You are given three lenses  $L_1$ ,  $L_2$  and  $L_3$  each of focal length 20 cm. An object is kept at 40 cm in front of  $L_1$ , as shown. The final real image is formed at the focus 'I' of  $L_3$ . Find the separation between  $L_1$ ,  $L_2$  and  $L_3$ . [ 3 ]



- 32.I.ii. Equi-convex lenses are to be manufactured from a glass of refractive index 1.55, with both faces of the same radius of curvature. What is the radius of curvature required if the focal length is to be 10cm? [ 2 ]

(OR)

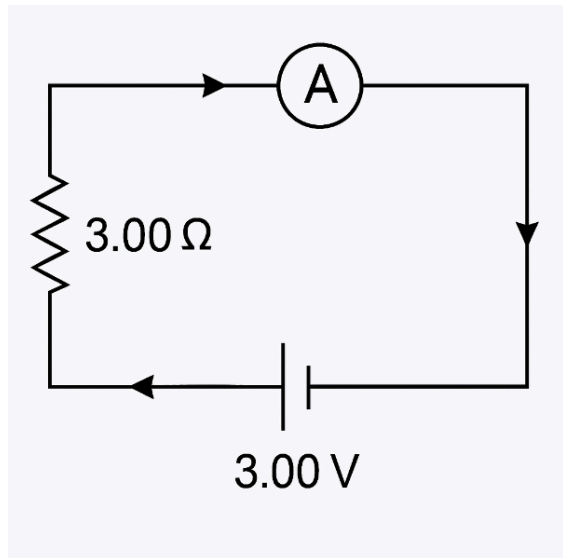
- 32.II. (a) Draw a ray diagram showing the image formation by an astronomical telescope when the final image is formed at infinity. [ 5 ]
- (b) (i) A small telescope has an objective lens of focal length 140 cm and an eyepiece of focal length 5.0 cm. Find the magnifying power of the telescope for viewing distant objects when the telescope is in normal adjustment and the final image is formed at the least distance of distinct vision.
- (ii) Also find the separation between the objective lens and the eyepiece in normal adjustment.

33.I.i. In the circuit the current is to be measured. What is the value of the current if the ammeter shown [ 3 ]

(a) is a galvanometer with a resistance  $R_G = 60.00 \Omega$ ;

(b) is a galvanometer described in (a) but converted to an ammeter by a shunt resistance  $r_s = 0.02 \Omega$ ;

(c) is an ideal ammeter with zero resistance?



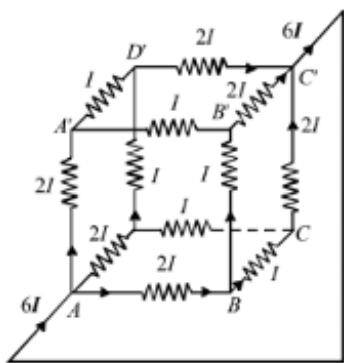
33.I.ii. (a) A current-carrying circular loop is located in a uniform external magnetic field. If the loop is free to turn, what is its orientation of stable equilibrium? Show that in this orientation, the flux of the total field (external field + field produced by the loop) is maximum. [ 2 ]

(b) A loop of irregular shape carrying current is located in an external magnetic field. If the wire is flexible, why does it change to a circular shape?

**(OR)**

33.II. i. State Kirchhoffs rules. [ 5 ]

ii. A battery of 10 V and negligible internal resistance is connected across the diagonally opposite corners of a cubical network consisting of 12 resistors each of  $1 \Omega$  resistance.



Use Kirchhoffs rules to determine

a. the total current in the network.

b. the equivalent resistance of the network

**ALL THE BEST**