CBSE Class 12 Physics

Sample Paper - 05 (2019-20)

Maximum Marks: 70

Time Allowed: 3 hours

General Instructions:

i. All questions are compulsory. There are 37 questions in all.
ii. This question paper has four sections: Section A, Section B, Section C and Section D.
iii. Section A contains twenty questions of one mark each, Section B contains seven questions of two marks each, Section C contains seven questions of three marks each, and Section D contains three questions of five marks each.
iv. There is no overall choice. However, internal choices have been provided in two questions of one mark each, two questions of two marks, one question of three marks and three questions of five marks weightage. You have to attempt only one of the choices in such questions.

Section A

1. A charge Q is placed at the mouth of a conical flask. The flux of the electric field through the flask is

    a. $\frac{Q}{\epsilon_0}$

    b. zero

    c. $\frac{Q}{2\epsilon_0}$

    d. $\frac{Q^2}{2\epsilon_0}$

2. Electric field lines can be said to be

    a. graphical representation of electric fields

b. lines of equal Electric field

c. drawing lines of electric fields

d. lines of equal Electric voltage

3. For a charged conductor of arbitrary shape, inside the conductor

a. V= 0 and $\mathrm{E} \neq 0$

b. E and V are zero

c. E = 0, but V is same as on the surface and non-zero

d. E is non-uniform but V is zero everywhere

4. An electrolytic capacitor is marked 8 $\mu\mathrm{F}$, 220 V. It can be used in a circuit where the p.d. across the capacitor may be
a. 200 V
b. 300 V
c. 1000 V
d. 500 V

5. According to Gauss's law for magnetism

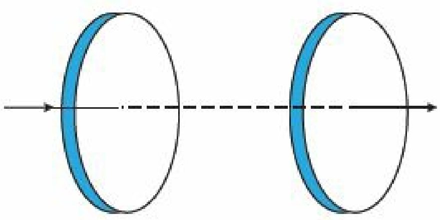
a. $\oint \vec{B}.\overrightarrow{ds} = 0$

b. $\int \vec{B}.\overrightarrow{ds} = 0$

c. $\oint \vec{B}.\overrightarrow{ds} = \mu_0$

d. $\int \vec{B}.\overrightarrow{ds} = \mu_0$

6. Figure shows a capacitor made of two circular plates each of radius 12 cm, and separated by 5.0 cm. The capacitor is being charged by an external source (not shown in the figure). The charging current is constant and equal to 0.15 A. Capacitance and the rate of charge of potential difference between the plates are



a. 74.1 $\mathrm{pF}, 1.87 \times 10^9 \mathrm{Vs}^{-1}$

b. 67.1 $\mathrm{pF}, 1.87 \times 10^9 \mathrm{Vs}^{-1}$

c. 80.1 $\mathrm{pF}, 1.87 \times 10^9 \mathrm{Vs}^{-1}$

d. 70.1 $\frac{1}{2} pF, 1.87 \times 10^9 \mathrm{Vs}^{-1}$

7. Approximate Doppler shift formula for light is

a. $\frac{\Delta v}{v} = -\frac{v_{rad}}{c}$

b. $\frac{\Delta v}{v} = 2\frac{v_{rad}}{c}$

c. $\frac{\Delta v}{v} = \frac{v_{rad}}{c}$

d. $\frac{\Delta v}{v} = -\frac{v_{rad}}{2c}$

8. A light beam travels at 1.94 $\times 10^8 \mathrm{ms}^{-1}$ in quartz. The wavelength of the light in quartz is 355 nm. If this same light travels through air, what is its wavelength there?

a. 549nm

b. 620nm

c. 579nm

d. 600nm

9. A giant telescope in an observatory has an objective of focal length 19 m and an eye-piece of focal length 1.0 cm. In normal adjustment, the telescope is used to view the moon. What is the diameter of the image of the moon formed by the objective? The diameter of the moon is 3.5 $\times 10^6$ m and the radius of the lunar orbit round the earth is 3.8 $\times 10^8$ m

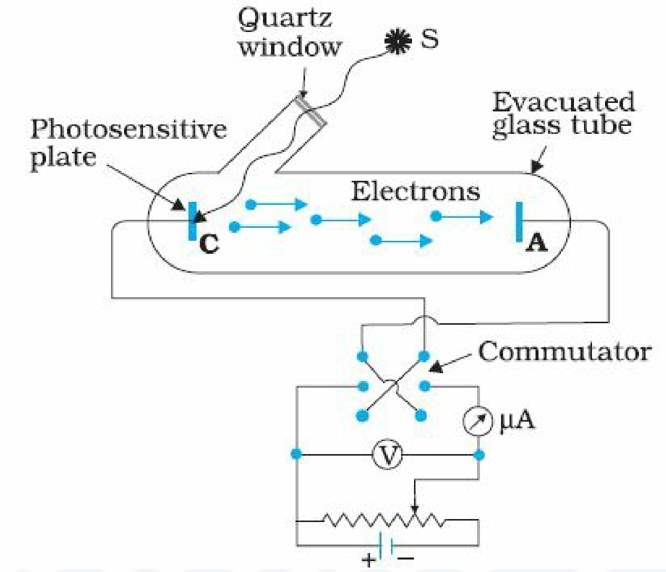
a. 18.5 cm

b. 19.5 cm

c. 21.5 cm

d. 17.5 cm

10. For a given frequency of light and a positive plate potential in the set up below, If the intensity of light is increased then



a. current is less with more intensity

b. current is inversely proportional to intensity

c. current is unaffected by more intensity

d. current is more with more intensity

11. Fill in the blanks:

Susceptibility is ________ for paramagnetic substances.

OR

Fill in the blanks:

When a bar is placed near a strong magnetic field and it is repelled, then the material of bar is ________.

12. Fill in the blanks:

    When a charged particle moves perpendicular to a magnetic field, then speed of the particle will ________.

13. Fill in the blanks:

    The magnetic force on a point charge is given by ________.

14. Fill in the blanks:

    Density of nucleus matter is the ratio of ________ of nucleus and its volume.

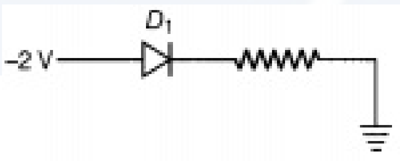
15. Fill in the blanks:

    The critical angle for a material of refractive index $\sqrt{2}$ is ________.

16. Draw a graph showing the variation of potential energy between a pair of nucleons as a function of their separation. Indicate the function in which the nuclear force is (i) attractive, (ii) repulsive.

17. Write the equation of decay of the radioactive nuclei.

18. Which type of biasing is there in the following diode?



19. Define the intensity of radiation on the basis of photon picture of light. Write its SI unit.

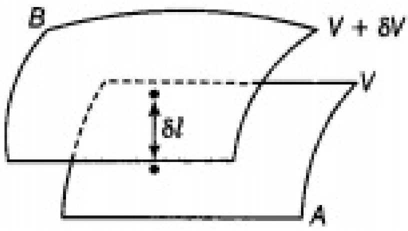
20. Draw a block diagram, of a generalized communication system.

OR

Is the ratio of the number of holes and the number of conduction electrons in an n-type extrinsic semiconductor more than, less than or equal to one?

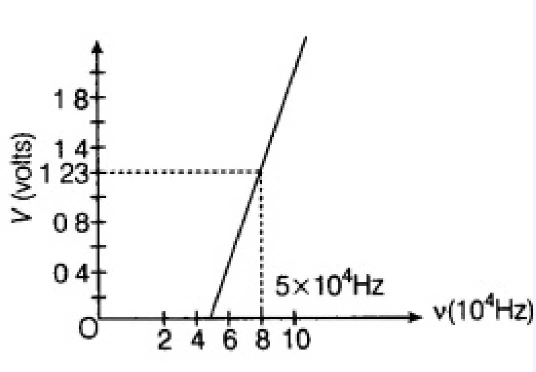
Section B

21. Two closely spaced equipotential surfaces A and B with potentials V and V + δV, (where δV is the change in V) are kept δl distance apart as shown in the figure. Deduce the relation between the electric field and the potential gradient between them. Write the two important conclusions concerning the relation between the electric field and electric potential.



22. What is the area of the plates of 2F parallel plate capacitor having separation between the plates is 0.5 cm?

23. Using the graph shown in the figure for stopping potential *versus* the incident frequency of photons, calculate Planck's constant.



24. i. Write the conditions under which light sources can be said to be coherent.
    ii. Why is it necessary to have coherent sources in order to produce an interference pattern?

25. Distinguish between diamagnetic and ferromagnetic materials in terms of

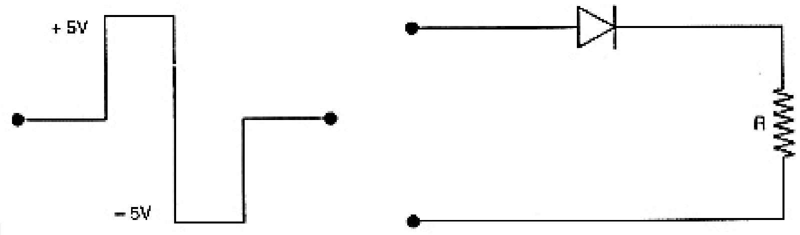
    i. susceptibility and
    ii. their behaviour in a non-uniform magnetic field.

26. A 12.5 eV electron beam is used to excite a gaseous hydrogen atom at room temperature. Determine the wavelengths and the corresponding series of the lines emitted.

OR

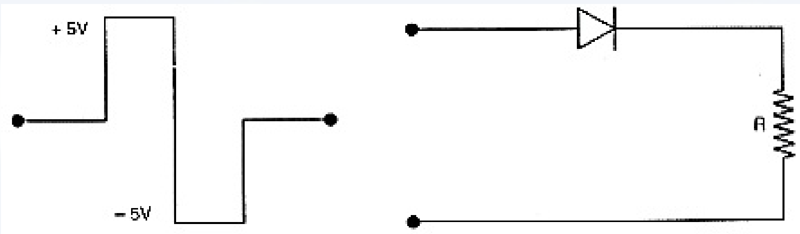
i. In hydrogen atom, an electron undergoes transition from second excited state to the first excited state and then to the ground state. Identify the spectral series to which these transitions belong.
ii. Find out the ratio of the wavelengths of the emitted radiations in the two cases.

27. Draw and explain the output waveform across the load resistor R, if the input waveform is as shown in the given figure.



OR

Draw and explain the output waveform across the load resistor R, if the input waveform is as shown in the given figure.



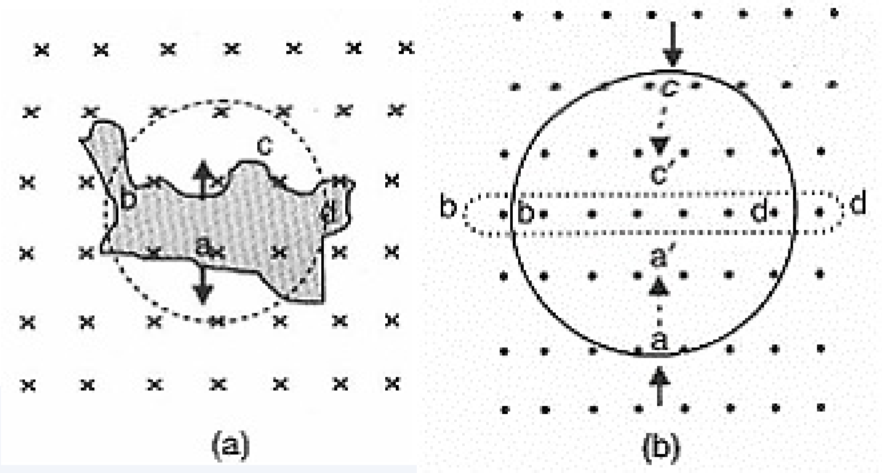
Section C

28. In a certain region of space, electric field is along the z-direction throughout. The magnitude of electric field is, however, not constant but increases uniformly along the positive z-direction, at the rate of 10^5 NC^{-1} per metre. What are the force and torque experienced by a system having a total dipole moment equal to 10^{-7}cm in the negative z-direction?

29. Three identical parallel plate capacitor (air) C_1, C_2, C_3 have capacitance C each. The space between their plates is now filled with dielectrics as shown. If all three capacitors still have equal capacitance, obtain the relation between dielectric constants, k, k_1, k_2, k_3 and k_4.

30. Use Lenz's law to determine the direction of induced current in the situation described by figure:

  a. A wire of irregular shape turning into a circular shape.
  b. A circular loop being deformed into a narrow straight wire.



31. What is intensity of electromagnetic wave? Give its relation in terms of electric field E and magnetic field B.

32. In Young's double slit experiment using monochromatic light the fringe pattern shifts by a certain distance on the screen when a mica sheet of refractive index 1.6 and thickness 1.964 microns is introduced in the path of one of the interfering waves. The mica sheet is then removed and the distance between the plane of the slits and the screen is doubled. It is found that the distance between the successive maximum now is the same as the observed fringe shift upon the introduction of mica sheet. Calculate the wavelength of the light.

OR

In a single slit diffraction experiment, when a tiny circular obstacle is placed in the path of light from a distant source, a bright spot is seen at the centre of the shadow of the obstacle. Explain why? State two points of difference between the interference pattern obtained in Young's double slit experiment and the diffraction pattern due to a single slit?

33. The value of ground state energy of hydrogen atom is -13.6 eV.

i. Find the energy required to move an electron from the ground state to the first excited state of the atom.
ii. Determine
   a. the kinetic energy and
   b. orbital radius in the first excited state of the atom.
   (Given, the value of Bohr's radius= 0.53 A)

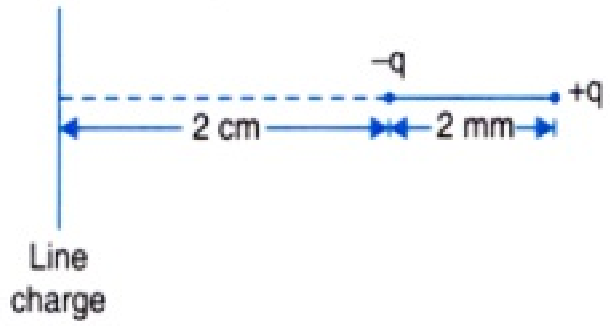
34. Explain, how a depletion region is formed in a junction diode?

Section D

35. Deduce the condition for balance in a Wheatstone bridge. Using the principle of Wheatstone bridge, describe the method to determine the specific resistance of a wire in the laboratory. Draw the circuit diagram and write the formula used. Write any two important precautions you would observe while performing the experiment.

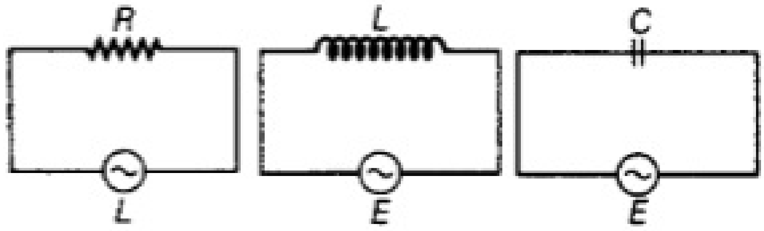
OR

a. State Gauss's law in electrostatics. Use this law to derive an expression for the electric field due to an infinitely long straight wire of linear charge density $\lambda\ cm^{-1}$.
b. An electric dipole consists of charges of $2.0 \times 10^{-8}C$ separated by a distance of 2 mm. It is placed near a long line charge of density $4.0 \times 10^{-4}cm^{-1}$ as shown in the figure below, such that the negative charge is at a distance of 2 cm from the line charge. Calculate the force acting on dipole.



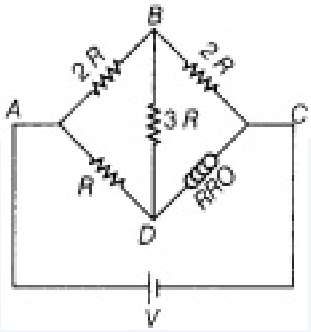
36. i. What do you understand by the sharpness of resonance in a series L-C-R circuit? Derive an expression for Q-factor of the circuit.
ii. Three electrical circuits having AC sources of variable frequency are shown in the figures. Initially, the current flowing in each of these is same. If the frequency of

the applied AC source is increased, how will the current flowing in these circuits be affected? Give the reason for your answer.



OR

i. Use Kirchhoffs rules to obtain the balance condition in a Wheatstone bridge.



ii. Calculate the value of R in the balance condition of the Wheatstone bridge, if the carbon resistor connected across the arm CD has the colour sequence red, red and orange, as shown in the figure.

iii. If now the resistance of the arms BC and CD are interchanged, to obtain the balance condition, another carbon resistor is connected in place or R. What would now be sequence of colour bands of the carbon resistor?

37. a. Draw a labelled ray diagram showing the formation of a final image by a compound microscope at least distance of distinct vision.

b. The total magnification produced by a compound microscope is 20. The magnification produced by the eyepiece is 5. The microscope is focused on a certain object. The distance between the objective and eyepiece is observed to be 14 cm. If least distance of distinct vision is 20 cm. Calculate the focal length of the objective and the eyepiece.

OR

An angular magnification of 30X is desired using an objective of focal length 1.25 cm and an eyepiece of focal length 5 cm. How will you set up the compound microscope?

Answer

Section A

1. (c) $\frac{Q}{2\epsilon_0}$

   Explanation:

   If Q is the charge enclosed by conical flask than the flux is $\phi = \frac{Q}{\in_0}$

   But the charge is placed at the mouth of flask so if we draw another imaginary flask over it the charge is surrounded by two flasks now so the charge through the flask now half of the previous value (shared by two flask) So

   $\phi = \frac{Q}{2\in_0}$

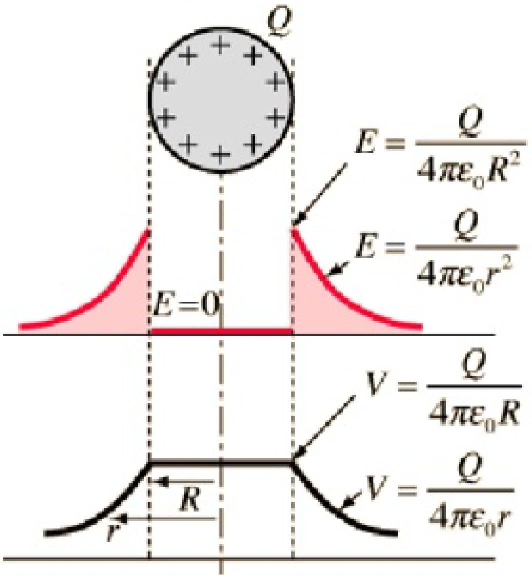
2. (a) graphical representation of electric fields
   Explanation: Electric Field Lines can be defined as a curve which shows direction of electric field, when we draw tangent at its point. The concept of electric field was proposed by Michael Faraday, in the 19th century. He always thought that electric field lines can be used to describe and interpret the invisible electric field. Instead of using complex vector diagram every time, This pictorial representation or form is called electric field lines.

   Electric field lines can be used to describe electric field around a system of charges in a better way.

3. (c) E = 0, but V is same as on the surface and non-zero
   Explanation: The electric field on the surface of a hollow conductor is maximum and it drops to zero abruptly inside the conductor.

   Since $E = -\frac{dV}{dr}$, the potential difference between any two points inside the hollow conductor is zero.
   This means that the potential at all points inside the hollow charged conductor is

same and it is equal to the value of the potential at its surface.



4. (a) 200 V Explanation: The break down potential of the capacitor is 220 V. In order to prevent damage to a capacitor, it should be always used in a circuit where the p.d is less than its break down potential. The p.d difference can only be 200 V.
5. (a) $\oint \vec{B}.\overrightarrow{ds} = 0$

   Explanation: Since magnetic monopoles do not exist, flux entering the closed surface is equal to flux leaving the surface. Hence net magnetic flux through a closed surface is zero.

6. (c) 80.1 $\frac{1}{2}pF, 1.87 \times 10^9 \text{Vs}^{-1}$

   Explanation:

   Capacitance,$C = \frac{\epsilon_o A}{d} = \frac{\epsilon_o \pi r^2}{d} \approx 80.1pF$
   q = CV
   Differentiating both the sides, $\frac{dq}{dt} = \frac{C\,dV}{dt}$
   or $I = \frac{C\,dV}{dt}$
   $\frac{dV}{dt} = \frac{I}{C} = \frac{0.15}{\left(80.01 \times 10^{-12}\right)}$
   $= 1.87 \times 10^9 V/s.$

7. (a) $\frac{\Delta v}{v} = -\frac{v_{rad}}{c}$

   Explanation: The fractional change in frequency ΔV/V is given by $-V_{radial}/c$, where V_{radial} is the component of the source velocity along the line joining the observer to the source relative to the observer; V_{radial} is considered positive when the source moves away from the observer.

8. (a) 549nm

   Explanation:

   $\mu = \frac{v_1}{v_2}$
   also, $\mu = \frac{\lambda_1}{\lambda_2}$
   this gives $\frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$
   putting these values, $v_1 = 1.94 \times 10^8, v_2 = 3 \times 10^8 and\ \lambda_1 = 355nm$
   so,$\lambda_2 = 549nm$

9. (d) 17.5 cm

   Explanation:

   Since moon is situated very far so its image is at the focal plane of objective lens.
   So angle subtended by diameter of moon is equal to angle subtended by the image,
   $\beta = \alpha$
   or $tan\beta = tan\alpha$
   or $\frac{d}{f_o} = \frac{D}{r}$; where D is diameter of moon and r is the distance of moon from the earth.
   $\therefore d = \frac{D \times f_o}{r} = \frac{3.5 \times 10^6 \times 19}{3.8 \times 10^8} = 17.5 \times 10^{-2} m = 17.5cm$

10. (d) current is more with more intensity

    Explanation: With increase in intensity no. of incident photon increases. So that more electron emitted from metal and photo current increases with increase in intensity.

11. Positive

    OR

    Diamagnetic

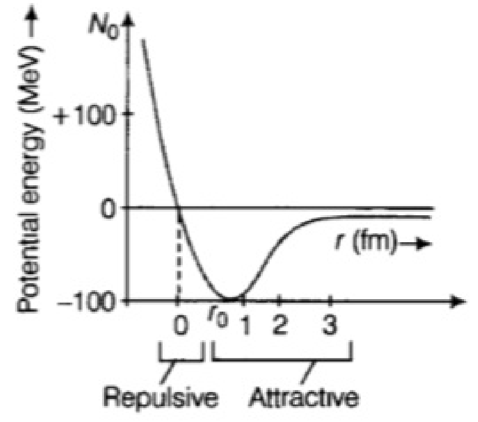
12. Remain unchanged

13. $\overrightarrow{F} = q(\overrightarrow{v} \times \overrightarrow{B})$

14. Mass

15. 45°

16. Plot of potential energy of a pair of nucleons as a function of their separation is given in the figure:



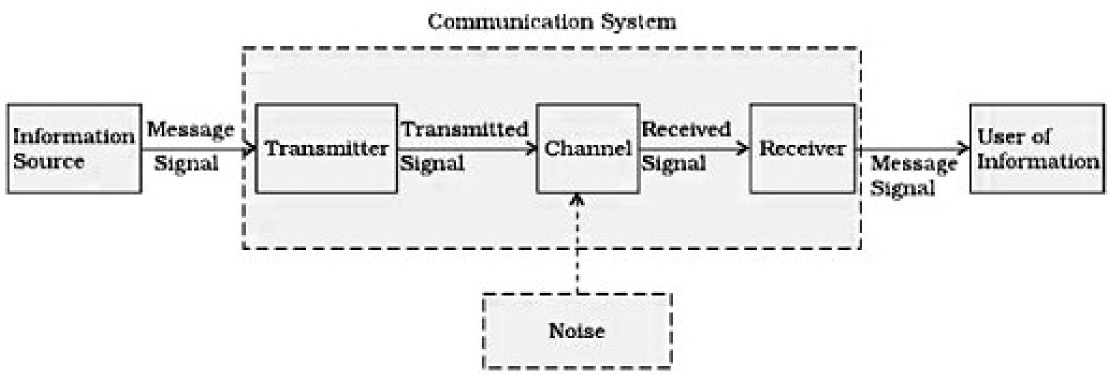
From the above graph it can be easily concluded that if distance between nucleons is greater than r_0, forces are attractive in nature while for separation less than r_0 , forces are attractive in nature.

17. $N = N_0 e^{-\lambda t}$

18. Reverse Biasing

19. The amount of light energy/photon energy, incident per metre square per second is called the intensity of radiation.

SI Unit: W/m^2

20. 

OR

In an n-type extrinsic semiconductor, the ratio of a number of holes to the number of electrons is less than one.

Section B

21. Work done in moving a unit positive charge along an infinitesimal distance δl,

$|E_I|\,\delta l = V_A - V_B = V - (V + \delta V) = -\delta V$ [since work done, w = $\vec{E}.\,\overrightarrow{\delta l}$ = q × (V_B - V_A) and charge,q = 1 unit here]

or $E = -\frac{\delta V}{\delta l}$

i. Electric field is in the direction in which the change in electrostatic potential decreases most. (This conclusion comes due to the negative sign of the above expression)
ii. Magnitude of electric field is given by the change in the magnitude of electrostatic potential per unit displacement normal to the equipotential surface at the point.

22. According to the question capacitance,C = 2 Farady

$d = 0.5\text{cm} = 0.5 \times 10^{-2}\text{m}$ (distance of separation between the two plates)

$\varepsilon_0 = 8.854 \times 10^{-12}\text{C}^2\text{N}^{-1}\text{m}^{-2}$ (permittivity of free space or vacuum)

As the capacitance of a parallel plate capacitor, $C = \frac{\varepsilon_0 A}{d}$

$\therefore \quad A = \frac{Cd}{\varepsilon_0} = \frac{2\times0.5\times10^{-2}}{8.854\times10^{-12}} = 1.13 \times 10^9\text{m}^2$

23. According to Einstein s photoelectric equation

eV = hv - ϕ_0

On differention, we get eΔv = hΔv

In the given graph :

or $h \;= \frac{e\Delta V}{\Delta v} = \frac{1.6\times10^{-19}\times(1.23-k)}{(8-5)\times10^{14}} \;= 6.56 \times 10^{-34}\text{J} - \text{s}$

24. i. Coherent sources: Two sources are said to be coherent in nature if they emit light of same frequency and of a stable path difference. The essential condition, which must be satisfied for the sources to be coherent are:

a. The two light waves should be of same wavelength.

b. The two sources must be very close to each other.
c. The two light waves should either be with same phase or should have a constant phase difference.
d. The two sources should preferably have the same amplitude.
e. The sources should emit light waves continuously.

ii. Two sources of emitting light waves of same frequency or wavelength and of a stable phase difference are required to see interference pattern, and we can obtain such nature of light waves from coherent source.
So, we require coherent sources to produce the interference of light.

25. i. **Susceptibility for diamagnetic material**
It is independent of magnetic field and temperature (except for bismuth at low temperature).
Susceptibility for ferromagnetic material
The susceptibility of ferromagnetic materials decreases steadily with increase in temperature. At the Curie temperature, the ferromagnetic materials become paramagnetic. The value of magnetic succeptibility is positive and much more greater than 1 for ferromagnetic materials.
ii. **Behaviour in non-uniform magnetic field**
Diamagnets are feebly repelled, whereas ferromagnets are strongly attracted by non-uniform field, i.e. diamagnets move in the direction of decreasing field, whereas ferromagnet feels force in the direction of increasing field intensity.

26. The wavelength of series emitted during transition is given by the formula:

$hc / E = \lambda$

E = 12.5 eV
hc = 1240 eV

Therefore wavelength of emitted series is:

$\lambda = 1240 / 12.5 = 99.2$ nm
This belongs to the Lyman series of Bohr's Hydrogen Spectrum.
therefore, The wavelength of emitted series is 99.2 nm and this belongs to the Lyman series of Bohr's Hydrogen Spectrum.

OR

i. When an electron undergoes transition from second excited state to the first excited state it is known as Balmer series and then to the ground state is known as Lyman series.

ii. The wavelength of the emitted radiations in the two cases, they are

For $n_2 \xrightarrow{\lambda_L} n_1$

$\Delta E = (-3.40 + 13.6) = 10.20eV$

$\lambda_L = \frac{12.43 \times 10^{-7}}{10.2} = 1.218 \times 10^{-7}\text{m}$

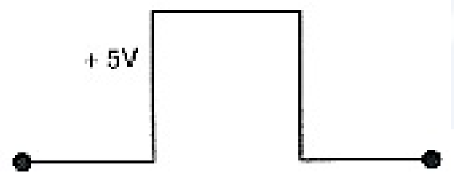
For $n_3 \xrightarrow{\lambda_B} n_2$

$\Delta E = (-1.5 + 3.4) = 1.9eV$

$\Rightarrow \quad \lambda_B = \frac{12.43 \times 10^{-7}}{1.9} = 6.54 \times 10^{-7}\text{m} = 6540\overset{o}{A}$

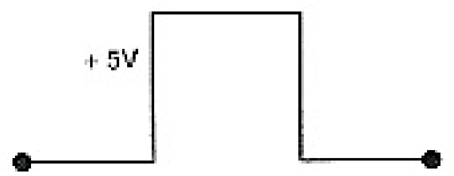
$\therefore \quad \frac{\lambda_B}{\lambda_L} = \frac{6540\overset{o}{A}}{1281\overset{o}{A}} = 5.10$

27. When the input voltage is +5V, the diode gets forward biased, the output across R is +5V, as shown in figure. When the input voltage is -5V , the diode gets reverse biased. No output is obtained across R.



OR

When the input voltage is +5V, the diode gets forward biased, the output across R is +5V, as shown in figure. When the input voltage is -5V , the diode gets reverse biased. No output is obtained across R.



Section C

28. Force acting on an electric dipole in the positive z-direction which is placed in a non-

uniform electric field.

$$F = p_x \frac{\partial E}{\partial x} + p_y \frac{\partial E}{\partial y} + p_z \frac{\partial E}{\partial z}$$

As, the electric field changes uniformly in the positive z-direciton, only,

Thus,

$$\frac{\partial E}{\partial z} = +10^5 NC^{-1} m^{-1}$$

$$\frac{\partial E}{\partial y} = 0 \text{ and } \frac{dE}{dx} = 0$$

As, the system has the total dipole moment equal to 10^{-7} cm in the negative z-direction.

Thus,

$p_x = 0$, $p_y = 0$, pz = -10^{-7}cm

$$\therefore F = 0 + 0 - 10^{-7} \times 10^5 = -10^{-2} N$$

It is indicated by the negative sign that the force 10^{-2}N acts in the negative z-direction.

In an electric field $\overrightarrow{E}$, the torque on dipole moment $\overrightarrow{P}$ is given by

$$\overrightarrow{\tau} = p \times \overset{\varphi}{E}$$

$$|\overrightarrow{\tau}| = pE \sin\theta$$

As $\overrightarrow{p}$ and $\overrightarrow{E}$ are acting in opposite direction,

$\theta = 180^\circ$ so, $|\overrightarrow{\tau}| = pE \sin 180^\circ = 0$

29. After introducing the dielectrics the capacitance of capacitors C_1, C_2 and C_3 respectively is given as

$$C = \frac{k\varepsilon_0 A}{d}, C = \frac{2\varepsilon_0 A}{d}\left[\frac{k_1 k_2}{k_1 + k_2}\right] C = \frac{\varepsilon_0 A}{2d}[k_3 + k_4]$$

$$\Rightarrow \frac{k\varepsilon_0 A}{k} = \frac{2\varepsilon_0 A}{d}\left(\frac{k_1 k_2}{k_1 + k_2}\right) = \frac{\varepsilon_0 A}{2d}(k_3 + k_4)$$

$$\Rightarrow k = \frac{2k_1 k_2}{k_1 + k_2} = \frac{k_3 + k_3}{2}$$

30. a. When a wire of irregular shape turns into a circular loop, area of the loop tends to increase. Therefore, magnetic flux linked with the loop increases. According to Lenz's law, the direction of induced current must oppose the magnetic field, for which induced current should flow along adcba.
    b. In this case, the magnetic flux tends to decrease. Therefore, induced current must

support the magnetic field for which induced current should flow along adcba.

31. Intensity of electromagnetic wave is defined as the energy crossing per second per unit area perpendicular to the direction of propagation of electromagnetic waves. The intensity of electromagnetic wave at a point is;

$I = U_{av}c$

where $U_{av} = \frac{1}{2}\varepsilon_0 E_0^2 = \frac{1}{2}\frac{B_0^2}{\mu_0}$

and c is the velocity of electromagnetic wave,

$\therefore I = \frac{1}{2}\varepsilon_0 E_0^2 c = \frac{1}{2}\frac{B_0^2}{\mu_0}c$

Here E_0 and B_0 are maximum values of electric field and magnetic field respectively.

32. Due to introduction of mica sheet, the shift on the screen

$Y_0 = \frac{D}{d}(\mu - 1)t$

Now, when the distance between the plane of slits and screen is changed from D to 2D, fringe width will become,

$\omega = \frac{2D}{d}(\lambda)$

According to given problem,

$\frac{D}{d}(\mu - 1)t = \frac{2D\lambda}{d}$

$t = \frac{2\lambda}{(\mu-1)}$

or $\lambda = \frac{(\mu-1)t}{2}$

$= \frac{(1.6-1)\times 1.964\times 10^{-6}}{2}$

$= 5892\text{Å}$

OR

Waves diffracted from the edge of circular obstacle interfere constructively at the center of the shadow of the obstacle resulting in the formation of a bright spot.

Characteristics	**Interference**	**Diffraction**
Fringe width	All bright and dark fringes are of	The central bright fringe have got double width to that of width of secondary maxima or minima.

	equal width	
Intensity of bright fringes	All bright fringes are of same intensity	Central fringe is the brightest and intensity of secondary maxima, decreases with the increase of order of secondary maxima on either side of central maxima.

33. i. We know Energy of electron in nth orbit of hydrogen atom is

$E_n = \frac{-13.6}{n^2}\text{eV}$

For n =1$\Rightarrow E_1 = \frac{-13.6}{1^2}\text{eV}$ = -13.6 eV

For n = 2 $\Rightarrow E_2 = \frac{-13.6}{2^2}\text{eV}$ = -13.6/4 = -3.4 eV

Energy required = E_2 - E_1 = -3.4- (-13.6)= 10.2eV

ii.

a. Kinetic energy= - (Total energy of the electron in first excited state). = -(- 3.4) = 3.4 eV

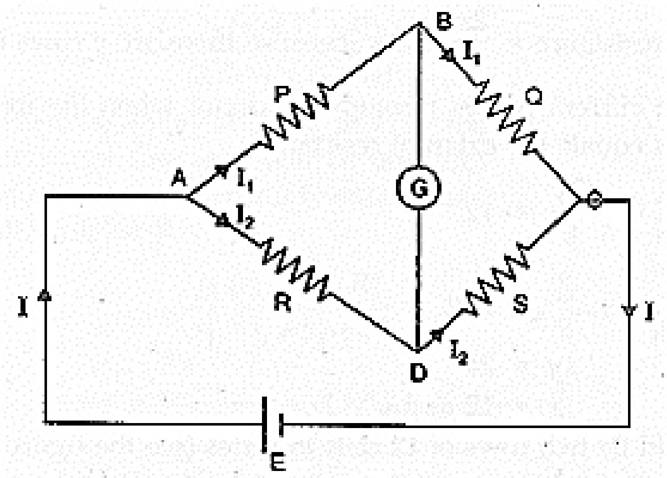
b. Orbital radius in the excited state,

$r = r_0 n^2 = (0.53\times10^{-10})\times(2)^2 = 0.53\times10^{-10}\times4 = 2.12\overset{o}{A}$

34. When p and n semiconductors are joined , the holes from p-region diffuse into the n-region and electrons from n-region diffuse into p-region and electron-hole pair combine and energy is released.
This process develops layer of positive ions near the junction on n side and layer of negative ions on p side of junction it develops ,V_B across the junction which opposes the further diffusion through the junction. Thus, small region forms in the vicinity of the junction which is depleted of free charge carrier and has only immobile ions is called the depletion region.

Section D

35. Four resistances P, Q, R and S are connected to form quadrilateral ABCD. A galvanometer G is connected between B and D. A battery is connected between A and C. The resistances are so adjusted that no current flows in the galvanometer G. The same current I_1 will flow in arms AB and BC. Similarly, current I_2 flows in arms AD and DC.



Applying Kirchhoff's second law for mesh ABCD,

$I_1P - I_2R = 0$

or $I_1P = I_2R$ ...(i)

For mesh BCDB,

$I_1Q - I_2S = 0$

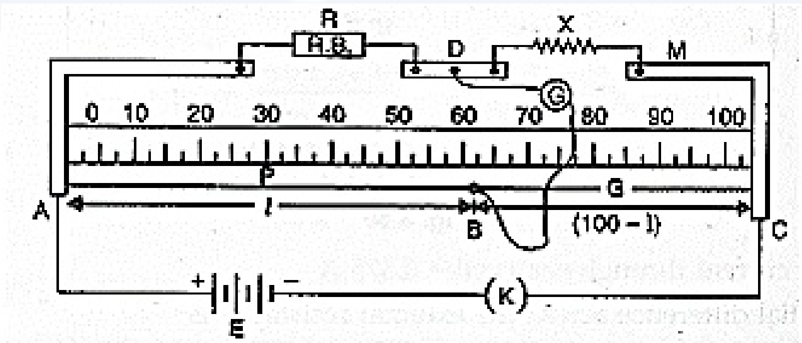
or $I_1Q = I_2S$ ...(ii)

Dividing (i) by (ii) we get

$\frac{P}{Q} = \frac{R}{S}$

This is the balanced condition of the Wheatstone bridge.

Measurement of specific resistance: Slide wire or meter bridge is a practical form of Wheatstone bridge.



In the figure X is unknown resistor and R.B is resistance box. After inserting the key k, jockey is moved on wire AC till galvanometer shows no deflection (point B). If k is the resistance per unit length of wire AC.

P = resistance of AB = kl

Q = resistance of BC = k(100 - l)

$\therefore \frac{R}{X} = \frac{P}{Q} = \frac{kl}{k(100-l)}$

or $X = \frac{(100-l)R}{l}$

If r is the radius of wire and l be its length, then its resistivity will be

$\rho = \frac{XA}{l'} = \frac{\pi r^2 X}{l'}$

Precautions:

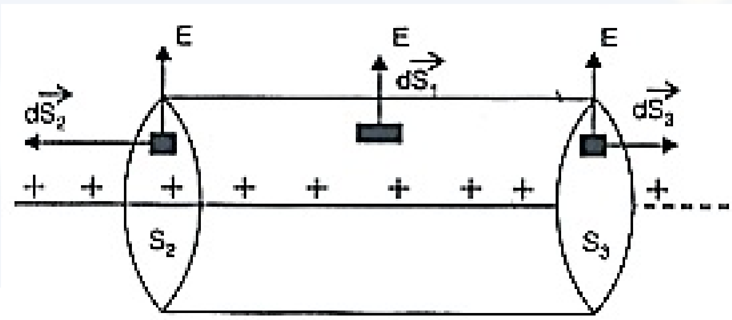
i. The null point should lie in the middle of the wire.
ii. The current should not be allowed to flow in the wire for a long time.

OR

a. Gauss's law in electrostatics: It states that total electric flux over the closed surface S in vacuum is $\frac{1}{\varepsilon_0}$ times the total charge (q) contained in side S.

$\therefore \phi_E = \oint\limits_S \overrightarrow{E} \cdot \overrightarrow{dS} = \frac{q}{\varepsilon_0}$

Let an infinitely long line charge having linear charge density λ. Assume a cylindrical Gaussian surface of radius r and length l coaxial with the line charge to determine its electric field at distance r.



Total flux through the cylindrical surface,

$\oint \overrightarrow{E} \cdot \overrightarrow{ds} = \oint\limits_{S_1} \overrightarrow{E} \cdot \overrightarrow{dS_1} + \oint\limits_{S_2} \overrightarrow{E} \cdot \overrightarrow{dS_2} + \oint\limits_{S_3} \overrightarrow{E} \cdot \overrightarrow{dS_3}$

$= \oint\limits_{S_1} E dS_1 \cdot \cos 0^\circ + \oint\limits_{S_2} E dS_2 \cdot \cos 90^\circ + \oint\limits_{S_3} E dS_3 \cdot \cos 90^\circ$

$= E \oint dS_1 = E \times 2\pi rl$

Since λ is the charge per unit length and l is the length of the wire,

Thus, the charge enclosed

$q = \lambda l$

According to Gaussian law,

$\oint\limits_S \overrightarrow{E} \cdot \overrightarrow{dS} = \frac{q}{\varepsilon_0}$

or, $E \times 2\pi r l = \frac{\lambda l}{\varepsilon_0}$

$\therefore E = \frac{\lambda}{2\pi\varepsilon_0 r}$

b. Electric field intensity at a distance r from line charge of density λ is

$E = \frac{\lambda}{2\pi\varepsilon_0 r}$

$\therefore$ Field intensity on negative charge (r = 0.02 m)

$E_1 = \frac{4\times10^{-4}\times9\times10^9\times2}{0.02} = 3.6 \times 10^8 N/C$

Force on negative charge

$F_1 = qE_1 = 2 \times 10^{-8}\left(3.6 \times 10^8\right) = 7.2N$

It is directed towards the line charge.

Similarly field intensity at positive charge (r = 0.022 m)

$E_2 = \frac{4\times10^{-4}\times9\times10^9\times2}{0.022} = 3.27 \times 10^8 N/C$

Force on positive charge

$F_2 = qE_2 = 2 \times 10^{-8}(3.27 \times 10^8) = 6.54N$

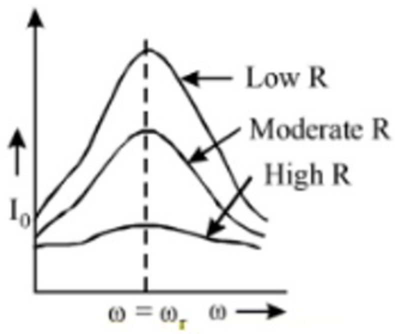
It is directed away from the line charge.

$\therefore$ Net force on the dipole,

$F = F_1 - F_2 = (7.2 - 6.54)N = 0.66$ N

F is towards the line charge.

36. i. The sharpness of resonance in series L-C-R circuit refers how quick fall of alternating current in circuit takes place when the frequency of alternating voltage shifts away from the resonant frequency. It is measured by the quality factor (Q-factor) of circuit.



The Q -factor of the series resonant circuit is defined as the ratio of the voltage developed across the capacitance or inductance at resonance to the impressed voltage which is the voltage applied.

i.e., quality factor (Q) = $\frac{\text{voltage across L or } C}{\text{applied voltage}}$

Q = $\frac{(\omega_r L)I}{RI}$

[∵ applied voltage = voltage across R]

or Q = $\frac{\omega_r L}{R}$ or Q = $\frac{(1/\omega_r C)I}{RI} = \frac{1}{RC\omega_r}$

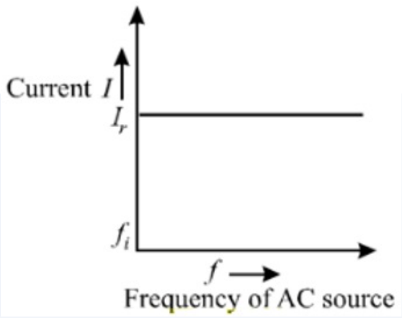
∴ Q = $\frac{L}{RC\cdot\frac{1}{\sqrt{LC}}}$ [using ω_r = $\frac{1}{\sqrt{LC}}$]

Thus, Q = $\frac{1}{R}\sqrt{\frac{L}{C}}$

This is required expression.

ii. Let initially I_r current is flowing in all the three circuits. If the frequency of applied AC source is increased then, the change in current will occur in the following manner:

Circuit containing resistance R only:



where, f_i = initial frequency of AC source.

There is no effect on current with the increase in frequency.

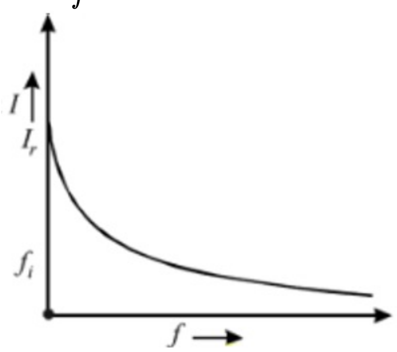
AC circuit containing inductance only:

With the increase of frequency of AC source, inductive reactance increase as

I = $\frac{V_{\text{rms}}}{X_L} = \frac{V_{\text{rms}}}{2\pi fL}$

For given circuit,

I $\propto \frac{1}{f}$



Current decreases with the increase of frequency.

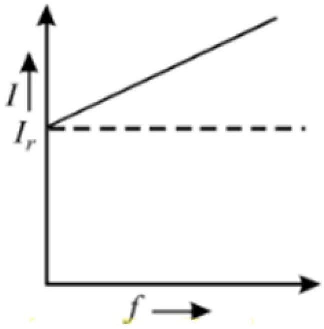
AC circuits containing capacitor only:

X_C = $\frac{1}{\omega C} = \frac{1}{2\pi fC}$

Current, I = $\frac{V_{\text{rms}}}{X_{\text{C}}}$ = $\frac{V_{\text{rms}}}{\left(\frac{1}{2\pi fC}\right)}$

I = $2\pi fCV_{\text{rms}}$

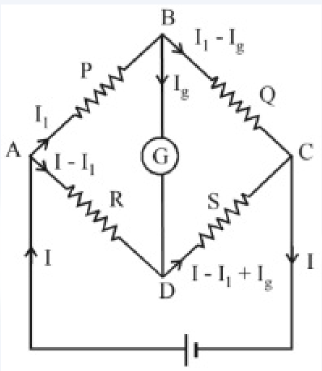
For given circuit, I $\propto$ f



Current increases with the increase of frequency.

OR

i. The balanced condition in Wheatstone bridge:



$\frac{P}{Q} = \frac{R}{S}$ or $\frac{P}{R} = \frac{Q}{S}$

ii. Let a carbon resistor S is given to the bridge arm CD. Then,

$\Rightarrow \frac{2R}{R} = \frac{2R}{S}$

$\therefore \frac{R}{S}$ = 1 $\Rightarrow$ R = S = 22 $\times$ 10^3 Ω

iii. After interchanging the resistances, the balanced bridge would be

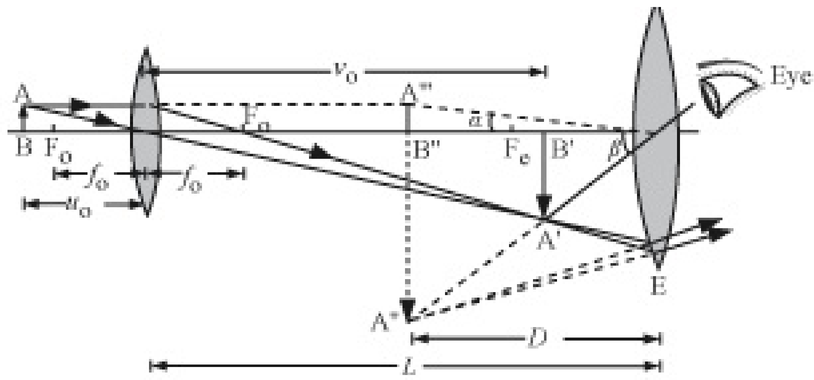
$\frac{2R}{X} = \frac{22\times10^3}{2\times22\times10^3} = \frac{1}{2}$

Here X is the resistance of arm AD

$\Rightarrow$ X = 4R = 4 $\times$ 22 $\times$ 103 = 88 kΩ

Hence colour code is Grey orange.

37. a.



where AB = object, A'B' = image formed by objective, A''B'' = image formed by eyepiece

L is the separation between the eyepiece and the objective,

f_0 is the focal length of the objective,

f_e is the focal length of the eyepiece,

D is the least distance for clear vision

b. For the least distance of clear vision, the total magnification is given by:

$m=-\frac{L}{f_o}\left(1+\frac{D}{f_e}\right)=m_o\cdot m_e$ ...(i)

Also, the given magnification for the eyepiece:

$m_e = 5 = \left(1+\frac{D}{f_e}\right)$

$\Rightarrow 5 = 1 + \frac{20}{f_e}$

$\Rightarrow f_e = 5$ cm

Substituting the value of m and m_e in equation (i), we get:

$m = m_0 . m_e$

$\Rightarrow m_o=\frac{m}{m_e}=\frac{20}{5} = 4$

Now, we have:

$m_o=\frac{L}{|f_o|}$

$\Rightarrow f_0 = \frac{14}{4} = 3.5$ cm

OR

In normal adjustment, image is formed at least distance of distinct vision,

d = 25 cm

Angular magnification of eyepiece $=\left(1+\frac{D}{f_e}\right)$

$= \left(1 + \frac{25}{5}\right) = 6$

Since the total magnification is 30, magnification of objective lens,

$m = \frac{30}{6} = 5$

$\therefore m = -\frac{v_0}{u_0} = 5$ or $v_0 = -5u_0$

As $\frac{1}{v_0} - \frac{1}{u_0} = \frac{1}{f_0}$

$\therefore \frac{1}{-5u_0} - \frac{1}{u_0} = \frac{1}{1.25}$

$-\frac{6}{5u_0} = \frac{1}{1.25}$

$u_0 = -\frac{6 \times 1.25}{5} = -1.5cm$

i.e. object should be held at 1.5 cm in front of objective lens.

As $v_0 = -5u_0$

$\therefore v_0 = -5\left(-1.5\right) = 7.5cm$

From $\frac{1}{v_e} - \frac{1}{u_e} = \frac{1}{f_e}$

$\frac{1}{u_e} = \frac{1}{v_e} - \frac{1}{f_e} = \frac{1}{-25} - \frac{1}{5} = -\frac{6}{25}$

$u_e = -\frac{25}{6} = -4.17cm$

Separation between the objective lens and eyepiece $= |u_e| + |v_0|$

= 4.17 + 7.5 = 11.67 cm