B.K. Birla Centre For Education

Date: 15-12-2025 | PRE BOARD EXAMINATION-II | **Duration**: 3 Hrs

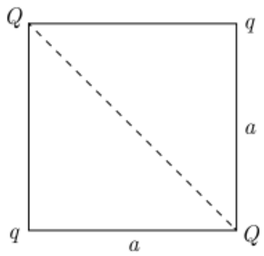
Class: XII | Physics | **Total Marks** : 70

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) $\frac{1}{\sqrt{2}}$

Answer

b) $2\sqrt{2}$ (1)

2. In Wheatstone's bridge P = 9 Ω , Q = 11 Ω, R = 4 Ω and S = 6 Ω. How much resistance must be put in parallel to the resistance S to balance the bridge? [1]

a) 24 Ω b) 28 Ω c) 26.4 Ω d) 24.6 Ω

Answer

c) 26.4 Ω (1)

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.

Answer

b) inductor decreases and the capacitor increases. (1)

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.

Answer

c) ultraviolet region. (1)

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

Answer ⚩

c) 54 (1)

6. A light source of wavelength λ 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 λ/ 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

Answer ⚩

b) 5 eV (1)

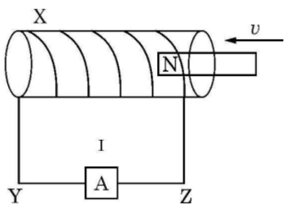
7. Which of the following statements is correct for alpha particle scattering experiment? [1]

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.

Answer ⚩

c) The number of alpha particles undergoing head-on collision is small. (1)

8. In the figure X is a coil wound over a hollow wooden pipe. [1]



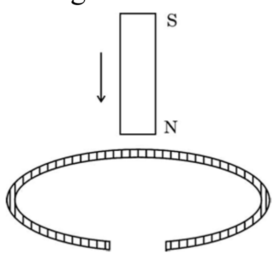
A permanent magnet is pushed at a constant speed v from the right into the pipe and it comes out at the left end of the pipe. During the entry and the exit of the magnet, the current in the wire YZ will be from

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

Answer ⚩

b) Y to Z and then Z to Y (1)

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

Answer ⚩

c) g (1)

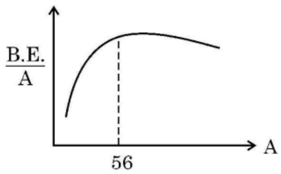
10. In an experiment, 200 V AC is applied at the ends of an LCR-circuit. The circuit consists of an inductive reactance of 50 Ω, capacitive reactance of 35Ω and ohmic resistance of 20 Ω. The impedance of the circuit is [1]

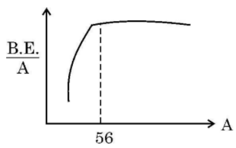
a) 15 Ω b) 25 Ω c) 35 Ω d) 45 Ω

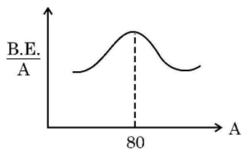
Answer

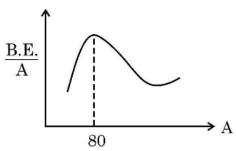
b) 25 Ω (1)

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]

a) 

b) 

c) 

d) 

Answer

b) (1)

12. A bar magnet having a magnetic moment of 2 x 10^4 JT^{-1} is free to rotate in a horizontal plane. A horizontal magnetic field 6 X10^{-4} 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

Answer

b) 6 J (1)

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

Answer

c) (A) is correct but (R) is wrong (1)

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

Answer ⚿

a) Both (A) and (R) are true and (R) is the correct explanation of (A) (1)

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.

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

Answer ⚿

a) Both (A) and (R) are true and (R) is the correct explanation of (A) (1)

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.

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

Answer ⚿

a) Both (A) and (R) are true and (R) is the correct explanation of (A) (1)

Section B

17. An electromagnetic wave Y_1 , has a wavelength of 1cm 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]

Answer ⚿

Y_1 has a wavelength of 1 cm, which lies in the microwave region. (0.5)

Y_2 has a frequency of 10^{15} Hz, which falls in the ultraviolet (UV) region. (0.5)

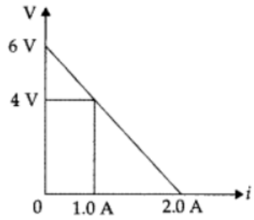
Y_1:Microwave Application: Used in microwave ovens for cooking food. (0.5)

Y_2:Ultraviolet (UV)wave Application: Used for sterilizing medical instruments (0.5)

18. The figure shows a plot of terminal voltage 'V' versus the current 'i' of a given cell. Calculate from the graph [2]

(a) emf of the cell and

(b) internal resistance of the cell



Answer

1) E = $6V$ (When I=0, no current drawn) (0.5)

2) E = $V + Ir$ (0.5)

3) 6 = $4 + 1\,(r)$ (0.5)

4) r = 2Ω (0.5)

19. A uniform electric field is represented as $\overrightarrow{E}$ = (3x 10^3N /C) $\hat{\imath}$. Find the electric flux of this field through a square of side 10 cm when the : [2]

(a) plane of the square is parallel to y-z plane, and

(b) the normal to plane of the square makes an angle of 60 with the x-axis.

Answer

1) $\Phi = \vec{E}.A\hat{\imath} = EA$ (0.5)

2) $3 \times 10^3 \times \left(100 \times 10^{-4}\right) = 30NC^{-1}m^2$ (0.5)

3) $\Phi = EA\cos 60^o$ (0.5)

4) $15NC^{-1}m^2$ (0.5)

20.I. A long solenoid has a magnetic field of 0.25T inside it. If a bar of magnetic susceptibility 5 is inserted into it what will be the magnetic flux density inside it? [2]

Answer

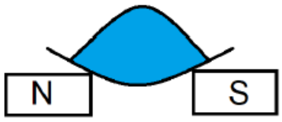
1) $\mu_r = 1 + X_m = 6$ (0.5)

2) $\mu_r = 0.25 \times 6$ (0.5)

3) $\mu_r = 1.5$ T (1)

(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

Answer

(i)The hump of the paramagnetic salt splits slowly into smaller mounds near the magnetic poles because higher thermal motion reduces magnetic susceptibility, so alignment is slower. (0.5)

(ii)Colder sample: The hump splits faster into smaller mounds near the magnetic poles, as lower thermal motion increases susceptibility, so the new arrangement is attained quicker. (0.5)

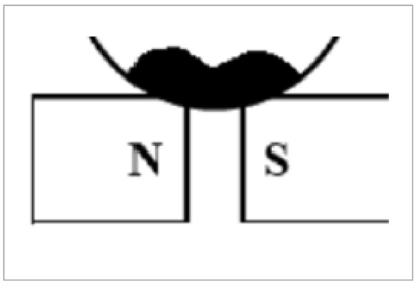


diagram (1)

21.I. In the Rutherford’s scattering experiment the distance of closest approach for an α −particle is d_0. [2]
If α −particle is replaced by a proton, how much kinetic energy in comparison to α particle will it require to have the same distance of closest approach d_0?

Answer

In Rutherford’s scattering experiment, the distance of closest approach is given by: (0.5)

$$d_0 = \frac{1}{4\pi\varepsilon_0} \frac{1}{K.E.q_1 q_2}$$

Where q_1 and q_2 are charges of the particle and nucleus.

For an α-particle: $q_\alpha = 2e$

For a proton: $q_p = e$

$$E_{K\alpha} = \frac{1}{4\pi\varepsilon_0} \frac{(Ze)(2e)}{d_0}$$ (0.5)

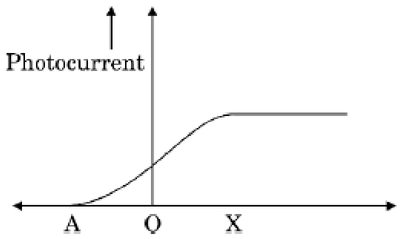
$$E_{Kp} = \frac{1}{4\pi\varepsilon_0} \frac{(Ze)(e)}{d_0}$$ (0.5)

$$E_{Kp} = \frac{1}{2} E_{K\alpha}$$ (0.5)

A proton requires half the kinetic energy of an α-particle to reach the same distance of closest approach d_0.

(OR)

21.II. The following graph shows the variation of photocurrent for a photosensitive metal: [2]

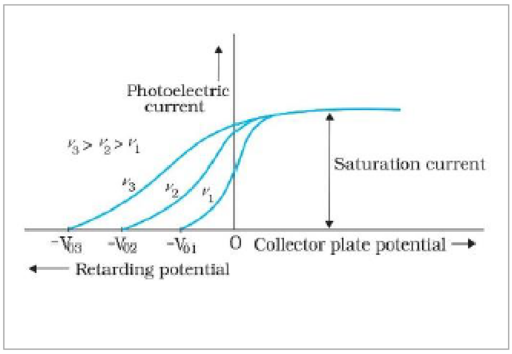


a) Identify the variable X and A on the horizontal axis.

b) Draw this graph for three different values of frequencies of incident radiation ν_1, ν_2 and ν_3 ($\nu_1 > \nu_2 > \nu_3$) for same intensity

Answer

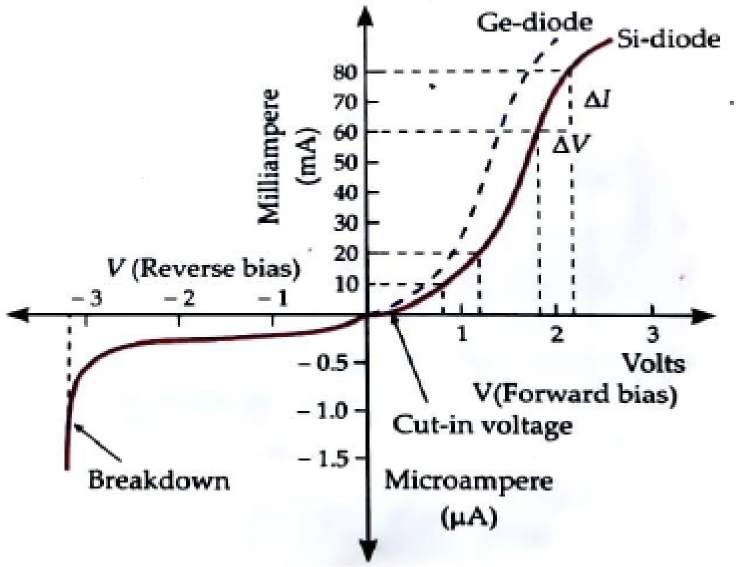
a) X is collector plate potential. A is stopping potential. (1)



graph (1)

Section C

22. The V-I characteristic of a silicon diode is given in fig. below. [3]



Calculate the diode resistance in :

(a) forward bias at V=+2 V and V=+1 V, and

(b) reverse bias V= -1 V and -2 V.

Answer

1) a) $r_f(at + 2\text{ V}) = \dfrac{(2.2 - 1.8)\text{V}}{(80 - 60)\text{mA}} = \dfrac{0.4\text{ V}}{20 \times 10^{-3}\text{ A}} = 20\Omega$ (0.5)

2) $r_f(at + 1\text{ V}) = \dfrac{(1.2 - 0.8)\text{V}}{(20 - 10)\text{mA}} = \dfrac{0.4\text{ V}}{10 \times 10^{-3}\text{ A}}$ (0.5)

3) $r_f(at + 1\text{ V}) = 40\Omega$ (0.5)

4) b) $r_r(at - 2\text{ V}) = \dfrac{-2\text{ V}}{-0.25\mu\text{ A}}$ (0.5)

5) $r_r(at - 2\text{ V}) = 8 \times 10^6\Omega$ (0.5)

6) $r_r(at - 1\text{ V}) = 8 \times 10^6\Omega$ (0.5)

23. A conductor of length I 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 [3]

i. drift speed of electrons and

ii. resistance of the conductor be affected? Justify your answer

Answer

i. Drift speed of electrons = $\frac{V}{nel\varrho}$ (1.5)

where, n is number of electrons, e is charge on electron, I is the length of the conductor and p is the resistivity of conductor. [∴ v∝1/ l ∵ other factors are constant] So, when length is tripled, drift velocity gets one-third.

ii. Resistance of the conductor is given as R=ρ(l/A) (0.5)

where ρ = Resistivity, l = length of the wire, A = Area of cross section of wire Here, wire is stretched to triple its length, that means the mass of the wire remains same in both the conditions.

Mass before stretching = Mass after stretching (Volume × Density) before stretching = (Volume (Area of cross-section × length) after stretching) ∴ (Density is same in both cases) (0.5)

$A_1 l_1 = A_2 l_2$ R ⇒ A_1 l = A_2 (3 l) [length is tripled after stretching]

∵ $A_2 = A_1/3$

When length is tripled area of cross-section is reduced to A/3. (0.5)

$R' = \rho \frac{l}{a} = \rho \frac{3l}{\frac{A}{3}} = 9\rho \frac{l}{A} = 9R$

Thus, above calculation shows that new resistance will be 9 times of its initial value.

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 = 1.007825u,
mass of neutron = 1.008665u . (given: 1 u = 931 MeV)

Answer

Step 1: Calculate the expected mass of constituent nucleons

The Bismuth-209 nucleus has 83 protons and 126 neutrons.

- Mass of 83 protons: $83 \times 1.007825\ \text{u} = 83.649475\ \text{u}$
- Mass of 126 neutrons: $126 \times 1.008665\ \text{u} = 127.091790\ \text{u}$
- Total expected mass: $83.649475\ \text{u} + 127.091790\ \text{u} = 210.741265\ \text{u}$

Step 2: Calculate the mass defect

The mass defect (Δm) is the difference between the total mass of the constituent nucleons and the actual mass of the nucleus.

$$\Delta m = (\text{Total nucleon mass}) - (\text{Actual mass of } ^{209}\text{Bi})$$

$$\Delta m = 210.741265\ \text{u} - 208.980388\ \text{u}$$

$$\Delta m = 1.760877\ \text{u}$$

I (1.5)

Step 3: Calculate the total binding energy

Convert the mass defect into energy units using the given conversion factor ($1\ \text{u} = 931\ \text{MeV}$).

$$\text{Binding Energy } (E_B) = \Delta m \times 931\ \text{MeV/u}$$

$$E_B = 1.760877\ \text{u} \times 931\ \text{MeV/u}$$

$$E_B \approx 1640.75\ \text{MeV}$$

Step 4: Calculate the binding energy per nucleon

The binding energy per nucleon is the total binding energy divided by the total number of nucleons (mass number A = 209).

$$\text{Binding Energy per Nucleon } (BE/A) = \frac{E_B}{A}$$

$$BE/A = \frac{1640.75\ \text{MeV}}{209\ \text{nucleons}}$$

$$BE/A \approx 7.85\ \text{MeV/nucleon}$$

II (1.5)

25. A spherical refracting surface with radius of curvature R=+20cm separates glass (n_1 =1.50) from air (n_2 =1.00). An object is located 30cm inside the glass, measured from the vertex of the surface. Using the refraction formula for a spherical surface, determine: [3]

(i) The position of the image formed (give the sign, medium, and nature of the image).

(ii) The linear magnification produced.

Answer

1) $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$ (0.5)

2) $\frac{1}{v} - \frac{1.50}{-30} = \frac{1.00 - 1.50}{20} \Rightarrow \frac{1}{v} + 0.05 = -0.025$ (0.5)

3) $\frac{1}{v} = -0.075 \Rightarrow v = -13.33$ cm (0.5)

4) (Negative v ⇒ image on object side, i.e. inside glass — virtual.) (0.5)

5) $m = \frac{n_1 v}{n_2 u} = \frac{1.50 \times (-13.33)}{1.00 \times (-30)}$ (0.5)

6) $m = 0.6667 \approx \frac{2}{3}$ (0.5)

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.

Answer

1

The objective lens of a telescope should have large focal length and large aperture so that it is able to gather more light and hence has better resolving power. (1)

2

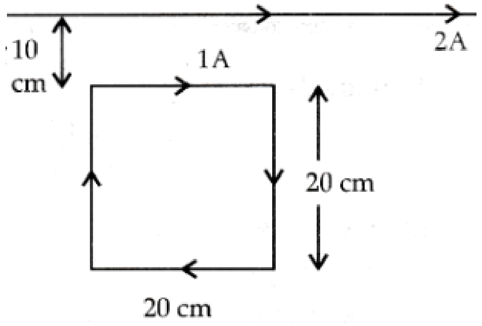
Two sodium lamps which are independent cannot emit coherent lights as two independent sources cannot produce waves which have no phase difference or have constant phase difference between them. (1)

3

$I = 4I_0 cos^2(\frac{\phi}{2})$ (0.5)

I is minimum for $\phi = \pi, 3\pi, \ldots \Rightarrow I_{min} = 0$ (0.5)

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.

Answer

1) $F = \dfrac{\mu_0 I_1 I_2}{2\pi d} l$ (0.5)

2) $\therefore\ Net\ force\ on\ side\ sab and cd\ = F_{inner} - F_{outer} = \dfrac{\mu_0 2 \times 1}{2\pi} \times 20 \times 10^{-2} \left[\dfrac{1}{10 \times 10^{-2}} - \dfrac{1}{30 \times 10^{-2}}\right]$ N (0.5)

3) $= 4 \times 10^{-7} \times 20 \left[\dfrac{20}{10 \times 30}\right] \text{N} = \dfrac{16}{3} \times 10^{-7}\ \text{N}$ (0.5)

4) $= 5.33 \times 10^{-7}\ \text{N}$ (0.5)

5) the direction is towards the infinite long straight wire (attractive). (1)

(OR)

27.II. A bar magnet of magnetic moment 2·5 JT^{-1} lies aligned with the direction of a uniform magnetic field of 0·32 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) ?

Answer

a) i) W=MB ($\cos\theta_2$ - $\cos\theta_1$) (1)

W=-2.5 x 0.22 (cos 90° -0°)

W= (2.5)(0.32) = 0.8 J

a) ii) W=MB ($\cos\theta_2$ $\cos\theta_1$) (1)

= - 2.5 * 0.22(cos 180° - 0°)

=-2(2.5)(0.32) = 1.6 J

b) For case (i), $\theta = \theta_2 = 90°$ (0.5)

:: Torque, τ = MB * sin θ

(2.5)(0.32)= 0.8J

For case (ii), $\theta = \theta_2 = 180°$ (0.5)

.: Torque, τ = MB X sin θ

= MB X sin 180°

= 0J

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

calculate :

(1) angular frequency of supply

(2) impedance of the circuit

Answer

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

$$\omega_0 = \frac{1}{\sqrt{(50 \times 10^{-3}\,\mathrm{H}) \times (80 \times 10^{-3}\,\mathrm{F})}}$$

$$\omega_0 = \frac{1}{\sqrt{4000 \times 10^{-6}\,\mathrm{s}^2}}$$

$$\omega_0 = \frac{1}{\sqrt{4 \times 10^{-3}\,\mathrm{s}^2}}$$

$$\omega_0 = \frac{1}{\sqrt{0.004}\ \mathrm{s}}$$

$$\omega_0 \approx 15.81\ \mathrm{rad/s}$$

formula (0.5)

substitute (0.5)

answer (0.5)

$$X_L = \omega_0 L$$

$$X_C = \frac{1}{\omega_0 C}$$

At resonance, $X_L - X_C = 0$.

The total impedance (Z) of the circuit is given by the formula:

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

At resonance, this simplifies to:

$$Z = \sqrt{R^2 + 0^2}$$

$$Z = R$$

Substitute the value of R:

$$Z = 20\,\Omega$$

2 formula (0.5)

substitute (0.5)

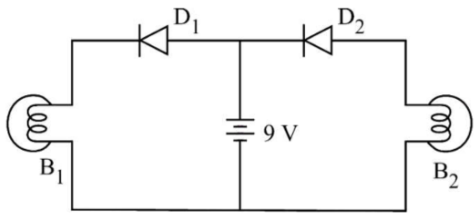
answer (0.5)

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]

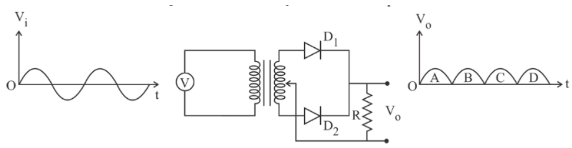


a) B1 only b) B2 only c) Both B1 and B2 d) Neither B1 nor B2

Answer ⚩

a) B1 only (1)

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

Answer ⚩

c) A, C (1)

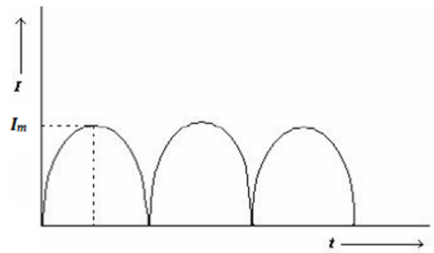
29.III. The output in a half-wave rectifier is : [1]

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

Answer ⚩

c) unidirectional with ripple (1)

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) $\frac{I_m}{\pi}$

Answer ⚩

c) $\frac{2I_m}{\pi}$ (1)

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]

Answer ⚩

The existence of a threshold frequency provides strong evidence for the particle nature (or quantum nature) of light. (1)

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

Answer ⚩

$E=h\nu=(6.63\times10^{-34})(7.0\times10^{14})=4.64\times10^{-19}$ J (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]

Answer ⚩

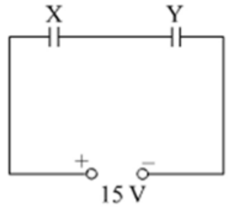
A metal surface illuminated by two light sources producing the same photoelectric current but having different frequencies means they eject the same number of electrons per second. (1)

This is possible because the current (number of electrons) is determined by the intensity of the light, specifically the number of photons hitting the surface per second, not the energy (frequency) of each photon. (1)

THOUGHTFULLY VARIED RESPONSE (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 $\varepsilon_r = 4$. [5]



(i) Calculate capacitance of each capacitor if equivalent capacitance of the combination is 4 μF.

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

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

Answer

1) $1. Here, C_X = \frac{\varepsilon_o A}{d}$ (0.5)

2) $C_y = \frac{\varepsilon_o \varepsilon_r A}{d} = 4C_X$ (0.5)

3) (i) Cx and Cy are in series, so equivalent capacitance is given by $C = \frac{C_X \times C_Y}{C_X + C_Y}$ (0.5)

4) $\Rightarrow 4 = \frac{C_X \times 4C_X}{C_X + 4C_X}$ $(\therefore C = 4\mu F)$ (0.5)

5) $\Rightarrow 4 = \frac{4C_X}{5}$ $\therefore C_X = 5\mu F$ and $C_Y = 4C_X = 20\mu F$ (0.5)

6) (ii) charge on each capacitor $Q = CV = 4 \times 10^{-6} \times 15 = 60 \times 10^{-6} C$ (0.5)

7) $V_X = \frac{Q}{C_X} = \frac{60 \times 10^{-6}}{5 \times 10^{-6}} = 12$ V (0.5)

8) $V_y = V - V_X = 15 - 12 = 3$V (0.5)

9) $\frac{U_X}{U_Y} = \frac{\frac{Q^2}{2C_X}}{\frac{Q^2}{2C_y}} = \frac{C_Y}{C_X} = \frac{4C_X}{C_X}$ (0.5)

10) $\frac{U_X}{U_Y} = 4$ (0.5)

(OR)

31.II.i. Two uniformly large parallel thin plates having charge densities +σ and – σ 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]

Answer

The equipotential surface is at a distance d/2 from either plate in X-Z plane. For a particle of charge (–q) at rest between the plates, then (i) Weight mg acts vertically downward (0.5)

(ii) Electric force qE acts vertically upward. (0.5)

so mg = qE (1)

$$E = \frac{mg}{q}$$

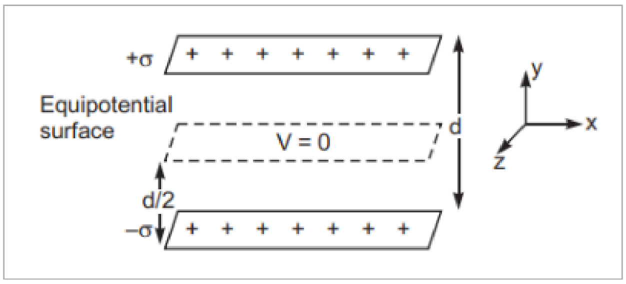
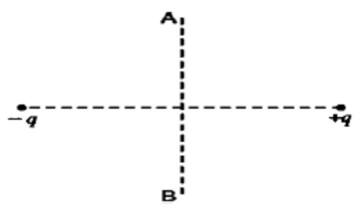


diagram (1)

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]



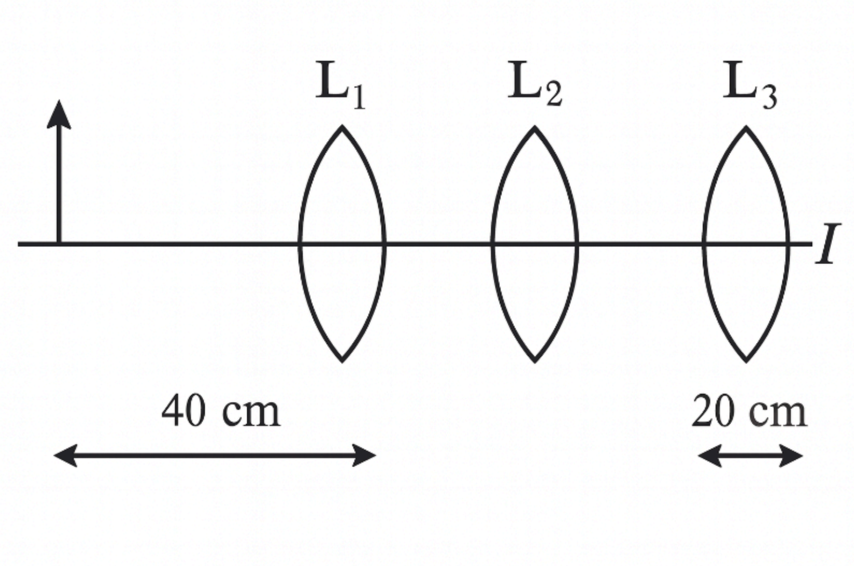
Answer

Work done in the process is zero. (0.5)

$W = q\,(V_B - V_A) = q \times 0 = 0$ (0.5)

Because equatorial plane of a dipole is equipotential surface and work done in moving charge on equipotential surface is zero. (1)

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]



Answer

b) $\frac{1}{v_1} - \frac{1}{u_1} = \frac{1}{f_1}$ (0.5)

$\Rightarrow \frac{1}{v_1} = \frac{1}{f_1} + \frac{1}{u_1}$

$\frac{1}{20} + \frac{1}{-40} = \frac{1}{40}$ (0.5)

Here, image by L 3 is formed at focus. (1)

So, the object should lie at infinity for L 3 .

Hence, L 2 will produce image at infinity.

So, we can conclude that object for L 2 should be at its focus. But, we have seen above that image by L 1 is formed at 40 right of L 1 which is at 20 cm left of L 2 (focus of L 2).

So, X 1 = distance between L 1 and L 2 = (40 + 20) c m = 60 c m . Again distance between L 2 and L 3 does not matter as the image by L 2 is formed at infinity. So, X 2 can take any value. (1)

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]

Answer

1) $(1/\mathrm{f}) = (\mu - 1)[(1/\mathrm{R}_1) - (1/\mathrm{R}_2)]$ (0.5)

2) $(1/10) = (1.55 - 1)[(1/\mathrm{R}) + (1/\mathrm{R})]$ (0.5)

3) $(1/10) = 0.55 \times (2/\mathrm{R})$ (0.5)

4) $Therefore \mathrm{R} = (0.55 \times 2 \times 10) = 11$ cm (0.5)

(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.

Answer

a) $m = \frac{\tan\beta}{\tan\alpha} = \frac{\beta}{\alpha}$ (0.5)

Final image is formed at infinity $m = \frac{h}{f_e} x \frac{f_0}{h}$ (0.5)

b(i) $m = -\frac{f_0}{f_e} = -\frac{140}{5} = -28$ (1)

$m = -\frac{f_0}{f_e}(1 + \frac{f_0}{D})$ (0.5)

$m = -\frac{140}{5}(1 + \frac{5}{25}) = -33.6$ (0.5)

(1)

ii) distance between lens = length of tube $= f_o + f_e = 140 + 5 = 145$cm

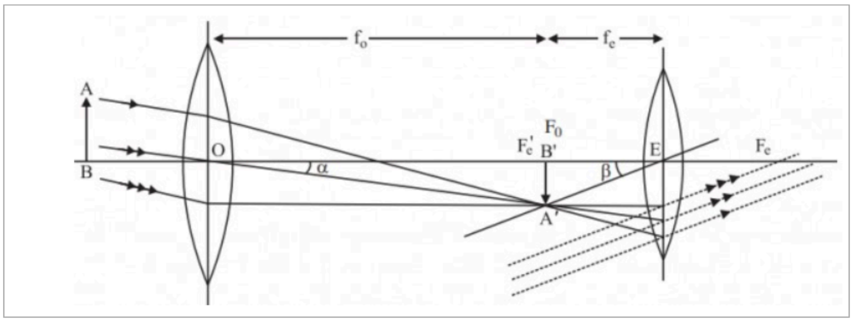


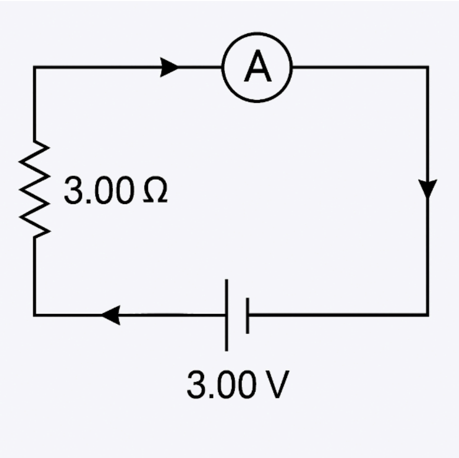
DIAGRAM (1)

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?



Answer

1) (a)Total resistance in the circuit is, = $R_G + 3$ (0.5)

2) I = $\frac{3}{63}$ =0.048 A. (0.5)

3) (b) $\frac{R_G r_s}{R_G + r_s} = \frac{60\Omega \times 0.02\Omega}{(60 + 0.02)\Omega} \simeq 0.02\Omega$ (0.5)

4) Total resistance in the circuit is = 0.02+ 3= 3.02 Ω (0.5)

5) $I = 3/3.02$ =0.09A (0.5)

6) (c) $I = 3/3$ =1A (0.5)

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?

Answer

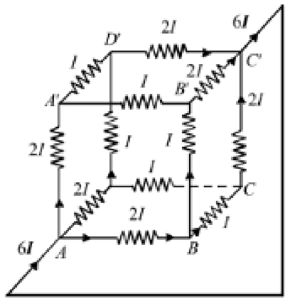
(a)Orientation of stable equilibrium is one where the area vector A of the loop is in the direction of external magnetic field. In this orientation, the magnetic field produced by the loop is in the same direction as external field, both normal to the plane of the loop, thus giving rise to maximum flux of the total field. (1)

(b)It assumes circular shape with its plane normal to the field to maximise flux, since for a given perimeter, a circle encloses greater area than any other shape. (1)

(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 1Ω resistance.



Use Kirchhoffs rules to determine

a. the total current in the network.

b. the equivalent resistance of the network

Answer

i) Kirchhoffs Ist rule or Junction Rule: The algebraic sum of electric currents at any junction of electric circuit is equal to zero (0.5)

Kirchhoff's IInd rule or Voltage Law: In any closed mesh of electrical circuit, the algebraic sum of emfs of cells and the product of currents and resistances is always equal to zero. (0.5)

a) Let 6I current be drawn from the cell. Since the paths AA', AD and AB are symmetrical, current through them is same. As per Kirchhoff's junction rule, the current distribution is shown in the figure. (0.5)

$E = V_A - V_B = (6I)R \Rightarrow 6IR = 10$ [$E = 10$ V] ....(i) (0.5)

$-2I\times1-I\times1-2I\times1+10=0$ (0.5)

$5I = 10 \Rightarrow I = 2A$ (0.5)

Total current in the network $= 6I = 6\times2 = 12$ A (0.5)

b) From Eq. (i), $6IR = 10$ (0.5)

$6\times2\times R = 10$ (0.5)

$R=\frac{10}{12}=\frac{5}{6}\,\Omega$ (0.5)