2009

Part: I

Question: 1

Answer all questions briefly and to the point. [20]

i. Explain the statement 'Relative permittivity of water is 81'.

Answer:

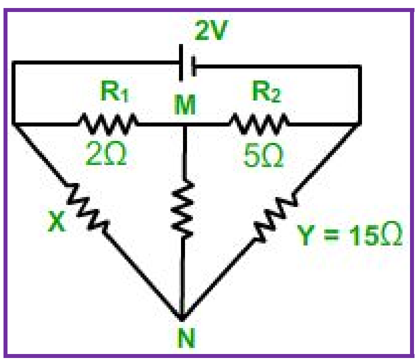
Relative permittivity of water is 81, means that force between two given charges held a given distance apart in water (K = 81) is only, $\frac{1}{81}$ of the force between them in air or vacuum.n

ii. Draw (at least three) electric lines of force due to an electric dipole.

Answer:

See topics on 'Concept of electric lines of force'.

iii.



Find the value of resistance X in the circuit above so that the junction M and N are at the same potential. (**)

iv. When the cold junction of a certain thermo-couple was maintained at 20 degree C, its neutral temperature was found to be 180 degree C. Find its temperature of inversion.

Answer:

We know,

$\theta_i = 2\theta_n - \theta_c$

$\theta_c = 20^0$ C

$\theta_n = 1800$

$\theta_i = ?$

$\theta_i = 2 \times 180 - 20 = 360 - 20 = 340^0C$

v. State how the magnetic susceptibility of a ferromagnetic changes when it is heated.

Answer:

Magnetic susceptibility varies inversely as abosolute temperature i.e as temperature increases magnitude susceptibility decreases.

vi. Write an equation of Lorentz force F acting on a charged particle having charge q moving in a magnetic field B with a velocity v in vector form.

Answer:

$\vec{F} = q\vec{v} \times \vec{B}$

vii. What is the value of power factor in a series LCR circuit at resonance?

Answer:

See topics on **'**Power factor'.

viii. An AC generator generates an emf 'e' given by: e = 311 Sin (100 pai t) volt. Find the rms value of the emf generated by the generator.

Answer:

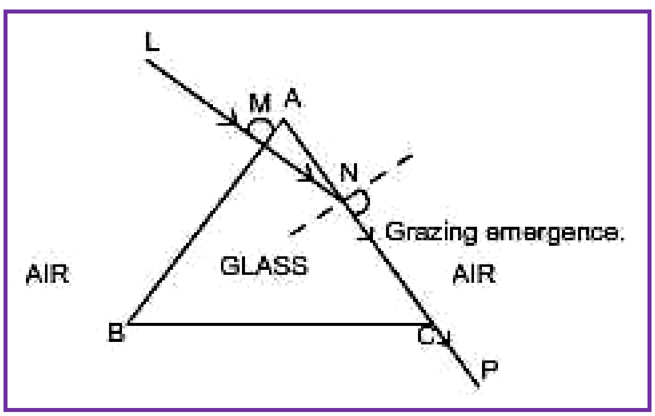
E = 311 Sin 100 πt

$E_{rms} = \frac{e_0}{\sqrt{2}}$

$= \frac{311}{\sqrt{2}}$

= 219.9 volt

ix. A ray LM of monochromatic light incident normally on one refracting surface AB of a regular glass prism ABC emerges in air from the adjacent surface AC as shown in the following figure. Calculate the refractive index of the material of the prism.



Answer:

$n = \frac{1}{\sin i_c}$

$n = \frac{1}{\sin 60}$

n = 1.15

x. Describe the absorption spectrum of Sodium.

Answer:

When light from the filament of an electric bulb passes through sodium vapor then two dark lines appear in the yellow part of continuous spectrum. This is known as absorption spectrum of sodium.

xi. A thin converging lens of focal length 15 cm is kept in contact with a thin diverging lens of focal length 20 cm. Find the focal length of this combination.

Answer:
Given,
f_1 = 15cm (convex),
f_2 = 20 cm(concave)

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$$
$$= \frac{1}{15} - \frac{1}{20}$$
$$= \frac{20-15}{300}$$
$$= \frac{5}{300}$$
$$= \frac{1}{60}$$

xii. Can two sodium vapor lamps act as coherent sources? Explain in brief.

Answer:
No, these lamps cannot act as coherent sources. This is because the phase difference between the light-waves emitted by such sources does not remain steady, but varies with time continuously.

Therefore, at any point on the screen the intensity of light also varies continuously, i.e. at the same point there is intense light at one instant and darkness at the other instant. This variation takes place so rapidly that, due to persistence of vision, our eyes are unable to note it.

To the eye the intensity of light at every point appears uniform, i.e. interference pattern (fringes) is not seen.

xiii. Why all over the world, giant telescopes are of reflecting type? State any one reason.

Answer:
Giant telescopes are of reflecting type because the image formed is brighter and free from chromatic aberration.

xiv. A ray of ordinary light is incident on a rectangular block of glass at Brewster's angle. What is the angle between the reflected ray and the refracted ray of light?

Answer:
Angle between the reflected and the refracted ray is 90^0.

xv. Find the momentum of a photon of energy 3.0 eV. *(**)*

xvi. The half life of a certain radio active element is 8 hours. If a pupil starts with 32 g of this element, how much of the sample will be left behind at the end of one day?

Answer:

$T_{1/2}$ = 8 hrs.

$N = N_0 \left(\frac{1}{2}\right)^n$

No. of half-lives:

$\frac{24}{8} = 3$

$N = 32\left(\frac{1}{2}\right)^3$

$= 32 \times \frac{1}{8}$

= 4 gm

xvii. If a hydrogen atom goes from III excited state to 11 excited states, what kind of radiation (visible light, ultra violet, infrared, etc.) is emitted?

Answer:

Visible light is emitted.

xviii. Where in our universe is the thermo-nuclear energy being released naturally?

Answer:

At the surface of the sun.

xix. In which of the solids (semi-conductors, conductors or insulators) do conduction band and valence band overlap?

Answer:

In conductors conduction band and valence band overlap.

xx. What is the symbol of a NOR gate?

Answer:

See topics on ‘NOR’

Part: II

Answer six questions in this part, choosing two questions from each of the Sections A, B and C

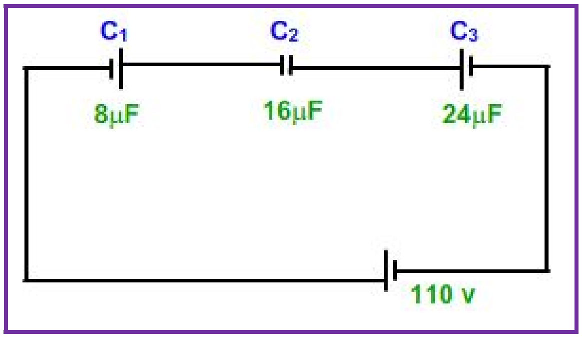
Section: A

Question: 2

a. With the help of a labeled diagram, obtain an expression for the electric field intensity ‘E’ at a point P in broad side position (i.e. equatorial plane) of an electric dipole. (**) [3]

Answer:

b. Find the electric charge Q_1 on plate of capacitor C_1, shown in figure below: [2]



Answer:

$\frac{48}{11}x110$

$\frac{1}{C}=\frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3}$

$=\frac{1}{8}+\frac{1}{16}+\frac{1}{24}$

$\frac{1}{C}=\frac{6+3+2}{48}=\frac{11}{48}$

$C=\frac{48}{11}\mu F$

= 480 µC

As all capacities are in series so charge will be the same on each capacitor.

c. [4]

i. What is meant by, Drift velocity and Relaxation time?

Answer:

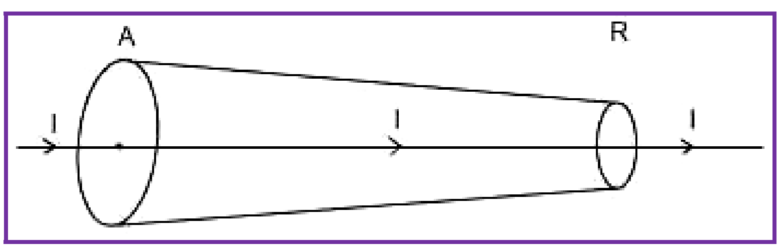
Drift velocity:

The free electrons in a metal do not move with a net velocity but instead it moves with an average velocity known as drift velocity.

Relaxation time:

Time internal between two successive collision's of a free electron with the positive in the metal.

ii. A metallic plug AB is carrying a current 1 (see figure below). State how the drift velocity of free electrons varies, if at all, from end A to end B.



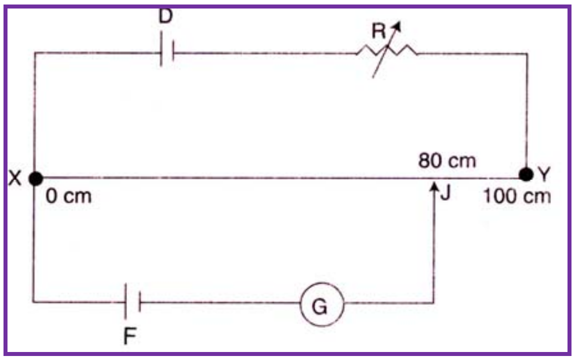
Answer:

In moving from A to B the area of cross section is decreasing.

So drift velocity increases as, $v_d = \frac{i}{neA}$

Question: 3

a. Figure below shows a uniform manganic wire XY of length 100 cm and resistance 9 ohm, connected to an accumulator D of emf 4V and internal resistance 1 ome through a variable resistance R, E is a cell of emf 1.8 V connected to the wire XY via a jockey J and a central zero galvanometer G. It is found that the galvanometer shows no deflection when XJ = 80 cm. Find the value of R. [3]



Answer:

E = K*l*

1.8 = K x 0.80

K = 2.25 v/m = 0.0225 v/cm

$K = \frac{V}{l}$

$0.0225 = \frac{V}{100}$

$2.25 = \frac{4}{10+R} x 9$

$10+R = \frac{9 x 4}{2.25}$

R = 6Ω

b. Obtain an expression for magnetic flux density 'B' at the center of a circular coil of radius R and having N turns, when a current I is flowing through it. [2]

Answer:

See topics on 'Tangent galvanometer'.

c. [4]

i. State any two differences between a moving coil galvanometer and a tangent galvanometer.

Answer:

.

Two differences between a moving coil galvanometer and a tangent galvanometer are:

- Moving coil galvanometer is a very sensitive device for measuring current as compared to tangent galvanometer.
- Moving coil galvanometer works on the principle that when current passes through it experiences a torque whereas tangent galvanometer works on tangent law in magnetism.

ii. What is the use of a Cyclotron? (**)

Question: 4

a. What is meant by the time constant of an LR circuit? When the current flowing through a coil P decreases from 5A to 0 in 0.2 seconds, an emf of 60V is induced across the terminals of an adjacent coil Q. Calculate the coefficient of mutual inductance of the two coils P and Q. [2]

Answer:
Time constant of a L-R circuit is the time in which the current grows from 0 to 0.632 of its steady value.

We know,

$$e = M\frac{di}{dt}$$

$$60 = M \times \frac{5}{0.2}$$

M = 2.4 henry.

b. When an alternating ernf e = 300 Sin (100 n t + n/6) volt is applied to a circuit, the current I through it Is I = 5.0 Sin (100 n t + n/6) ampere. Find the:

i. Phase difference between the emf and the current.

Answer:
Phase difference: $\frac{\pi}{6} + \frac{\pi}{6} = \frac{\pi}{3} = 60^0$

ii. Average power consumed by the circuit.

Answer:
Average power consumed

$= E_{rms} \times i_{rms} \times 60^0$

$= \frac{300}{\sqrt{2}} \times \frac{5}{\sqrt{2}} \times \cos 60^0$

= 375 watt

c. Obtain an expression for resonant frequency 'f0' of a series LCR circuit. [3]

Answer:
Let an alternating emf $E = E_0 \sin wt$ be applied across it, let 'I' is the current flowing through it.

$V_L = iX_L, V_C = iX_C, V_R = iR$
$E^2 = VR^2 + (V_L - V_C)^2$
$E^2 = i^2 [R^2 + (X_L - X_C)^2]$

$$i = \frac{E}{\sqrt{R^2 + (X_L - X_C)^2}}$$

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

$$\tan\phi = \frac{X_L - X_C}{R}$$

When, $\omega L = \frac{1}{\omega C}$

We have, $z = R$

Hence current will be maximum. This is the case of resonance.

$$\omega L = \frac{1}{\omega C}$$

$$\omega L = \frac{1}{\sqrt{LC}}$$

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

Section: B

Question: 5

a. In which part of' the electromagnetic spectrum, do the following radiations lie: [2]

i. Having wavelength of 20 nm

Answer:
X-rays

ii. Having frequency of 10 MHz

Answer:
Radio waves

b. In Young's double slit experiment, what is meant by 'fringe width' or 'fringe separation'? State two ways of increasing the fringe width, without changing the source of light. [3]

Answer:
See topics on 'Double slit interference'.

c. A thin convex lens which is made of glass (refractive index 1.5) has a focal length of 20 cm. It is now completely immersed in a transparent liquid having refractive index 1.75. Find the new focal length of the lens. [3]

Answer:
Given n = 1.5
f_a = 20 cm
n_l = 1.75
f_l = ?

$$\frac{\frac{1}{f_a}=\left({}_a\mu_g\right).\left(\frac{1}{R_1}-\frac{1}{R_2}\right)}{\frac{1}{f_l}=\left({}_l\mu_g-1\right).\left(\frac{1}{R_1}-\frac{1}{R_2}\right)}$$

$$\frac{f_l}{20}=\frac{0.5}{\left(\frac{1.5}{1.75}-1\right)}$$

f_l = -70 cm

Question: 6

a. Draw a labeled graph showing the variation in intensity of light with distance in a single slit Fraunhofer diffraction experiment. [2]

Answer:

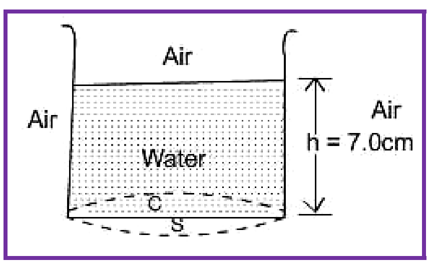
See topics on 'Single slit way'.

b. Give any two methods by which (ordinary) light can be polarized. [3]

Answer:

See topics on 'Polarization of light'.

c. A point source of monochromatic light 'S' is kept at the center C of the bottom of a cylinder. Radius of the circular base of the cylinder is 50.0 cm. The cylinder contains water (refractive index=4/3) to a height of 7.0 cm. (see figure below):



Find the area of water surface through which light emerges in air.(Take n = 22/7) [3]

Answer:

$a\mu_\omega=\frac{4}{3}$

h = 7cm

$\text{Sin}\,C=\frac{1}{4}$

$=\frac{1}{4/3}$

$=\frac{3}{4}$

C =48.5

$\tan C=\frac{\text{Perp}}{\text{Base}}$

$\text{Perp} = 7 \tan C$

$= 7 \times \tan 48.5$

$= 7.91$

so, radius = 7.91 cm

$A = \pi r^2$

$= \frac{22}{7} \times 7.91^2$

$= 196.64 \text{ cm}^2$

Question: 7

a. An astronomical telescope consists of two convex lenses having focal length 80 cm and 4 cm. When it is in normal adjustment, what is its: [3]

i. Length,

Answer:

$f_1 = 80$ cm

$f_2 = 4$ cm

length = $f_0 + f_e$

= 80 + 4 = 84 cm

ii. Magnifying power?

Answer:

$M = \frac{-f_o}{fe}$

$= \frac{-80}{4}$

$= 20$

b. A convex lens of focal length 5 cm is to be used as a simple microscope. Where should an object be kept so that image formed by the lens lies at least distance D of distinct vision (D=25 cm)? Also calculate the magnifying power of this instrument in this set up. [2]

Answer:

f = 5 cm

$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

$\frac{1}{5} = \frac{1}{-25} + \frac{1}{u}$

$\frac{1}{u} = \frac{1}{5} + \frac{1}{25}$

$\frac{1}{u} = \frac{6}{25}$

$u = \frac{25}{6} = 4.16 \text{cm}$

$M = 1 + \frac{D}{f}$

$=1+\frac{25}{5}=6$

b. What is meant by 'Chromatic aberration'? A thin convex lens of focal length 30 cm and made of flint glass (dispersive power = 0.03) is kept in contact with a thin concave lens of focal length 20 cm and made of crown glass. Calculate the dispersive power of crown glass if the above said combination acts as an achromatic doublet. [3]

Answer:
See topics on 'Chromatic'.

Numerical:

convexf_{flint}: 30 cm
$w_{flint} = 0.03$

concavef_{crown}: 20cm
w = ?

we know,

$\frac{w_1}{f_1}=\frac{w_2}{f_2}$

$\frac{0.03}{30}=\frac{w_2}{20}$

$w_2=\frac{20\,x\,0.03}{30}$

Section: C

Question: 8

a. Electrons, initially at rest, are passed through a potential difference of 2 kV. [2]
Calculate their:

i. Final velocity and

Answer:

We know, $\frac{1}{2}mv^2=ev$

$\frac{1}{2}$ x 9.1 x 10^{-31} x v2
= 1.6 x 10^{-19} x 2 x 10^3
v = 2.65 x 10^7 m/sec
'.

ii. de Broglie wavelength

Answer:

$\lambda=\frac{12.27}{\sqrt{V}}\mathring{A}$

$$=\frac{12.27}{\sqrt{2\times10^{3}}}$$

$$=0.274\,\overset{\circ}{A}$$

b. What are characteristic X rays? How are they different from continuous X rays? Give any one difference. [3]

Answer:
See topics on 'Continuous'.

c. Wavelength of the Ist line (H*a*) of Balmer series of hydrogen is 656.3 nm. Find the wavelength of its 2nd line (H*b*). [3]

Answer: .

$$\frac{\dfrac{1}{656.3\times10^{-9}}}{\dfrac{1}{\lambda}}=\frac{R\left(\dfrac{1}{2^{2}}-\dfrac{1}{3^{2}}\right)}{R\left(\dfrac{1}{2^{2}}-\dfrac{1}{4^{2}}\right)}$$

$$\frac{\lambda}{656.3\times10^{-9}}=\frac{\left(\dfrac{1}{4}-\dfrac{1}{9}\right)}{\left(\dfrac{1}{4}-\dfrac{1}{16}\right)}$$

$\lambda=3.04\times10^{8}$ m

Question: 9 (**)

a. Plot a labeled graph of |Vs| where Vs is stopping potential of photoelectrons versus frequency 'f' of incident radiation. How will you use this graph to determine the value of Planck's constant? Explain. [3]

b. Alpha particles having kinetic energy of 1.8 MeV each are incident on a thin gold foil, from a large distance. Applying the principle of conservation of energy, find the closest distance of approach of the alpha particle from the gold nucleus.(Atomic number of gold =79) [3]

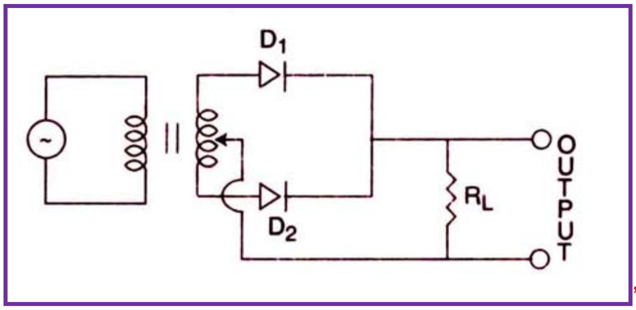
i. Define 'unified atomic mass unit'.
ii. Find the minimum energy, which a gamma ray photon should possess so that it is capable of producing an electron positron pair.

c. Fission of U - 235 nucleus releases 200 MeV of energy. Calculate the fission rate (i.e. no. of fissions per second) in order to produce a power of 320 MW. [2]

Question: 10

a. Draw a neatly labeled circuit diagram of a full wave rectifier using two junction diodes. [2]

Answer:
See topics on 'Full wave'.



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b. A sinusoidal voltage c = ro Sin (wt) is fed to a common emitter amplifier. Draw neatly labeled diagrams to show: [4]

i. Signal voltage
ii. Output voltage of the amplifier.

Answer:

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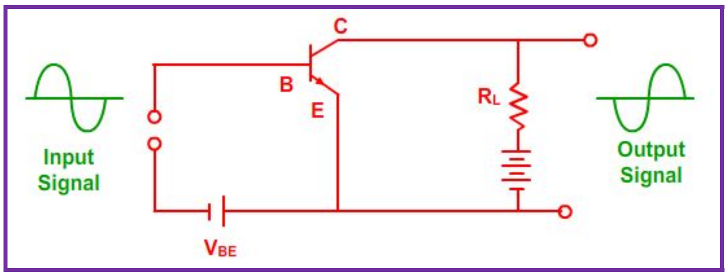
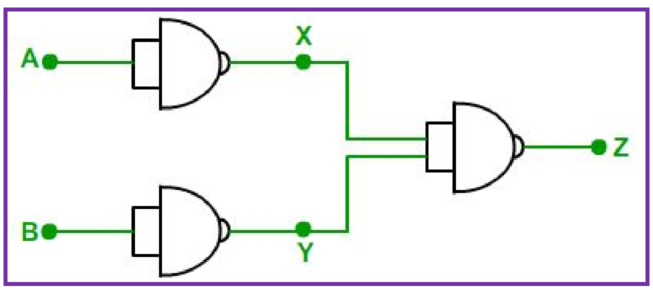


c. Make a truth showing input at A and B and output at X, Y and Z for the combination of gates shown in figure below. [2]



Answer:
’.

Truth table for the combination of gates is drawn below:

A	B	X	Y	Z
0	0	1	1	0
0	1	1	0	1
1	0	0	1	1
1	1	0	0	1

(**) Currently out of syllabus. Answer can be provided up on request.