2010

Set: I

Question: 1 – 29 ii – v

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Question: 1

Give two factors by which voltage sensitivity of a moving coil galvanometer can be increased. [3]

Answer:

- By increasing the number of turns in the galvanometer coil.
- By decreasing the torsion constant of the suspension fiber.

Question: 2

How does the maximum kinetic energy of emitted electron decreases with the increase in work function of the metal? [3]

Answer:

Maximum kinetic energy of emitted electron decreases with the increase in work function of the metal.

Question: 3

How does the frequency of a beam of ultraviolet light change when it goes from air into glass? [1]

Answer:

Frequency remains unchanged.

Question: 4

Define Bandwidth. [1]

Answer:

The range over which the frequencies in a signal vary is called the base band.)

Question: 5

Define Angle Modulation? [1]

Answer:

The phase angle θ, of the carrier wave is varied according to the base band signal, the amplitude of the carries wave kept is fixed. This mode of modulation is called Angle of modulation.)

Question: 6

What is the power dissipation in an AC circuit in which voltage and current are given by:
$V = 300 \sin(\omega t + \pi/2)$, and, $I = 5 \sin \omega t$ [1]

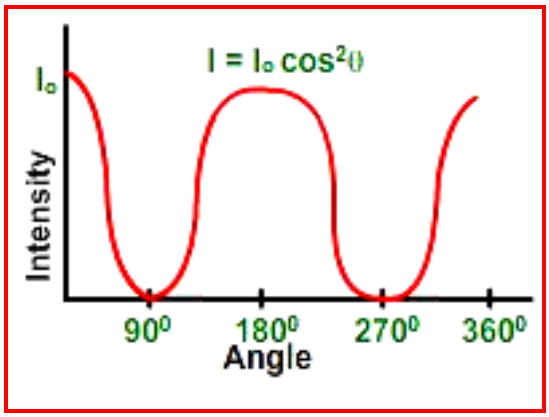
Answer:

As the phase difference between voltage and current is $\pi/2$, so power dissipation = 0.

Question: 7

Draw the graph showing the variation of intensity of polarized light transmitted by analyzer. [1]

Answer:



Question: 8

Give two defects of a voltaic cell.

Answer:

Two defects of a voltaic cell are,

- Local action
- Polarization

Question: 9

Define 'intensity of magnetization' of a magnetic material. How does it vary with temperature for a paramagnetic material?

Answer:

The intensity of magnetization is the magnetic moment developed per unit volume of a material when place in a magnetizing field. For a paramagnetic material, it is inversely proportional to the temperature.

Question: 10

A bar magnet of magnetic moment M is aligned parallel to the direction of a uniform magnetic field B. What is the work done, to turn the magnet, so as to align its magnetic moment:

i. Opposite to the field direction and
ii. Normal to the field direction

Answer:

$W = -MB (\cos \theta_2 - \cos \theta_1)$

i. $W = -MB (\cos 180^0 - \cos 0^0) = -MB (-1-1) = 2MB$
ii. $W = -MB (\cos 90^0 - \cos 0^0) = -MB (0-1) = MB$

Question: 11

Calculate the solar constant on a planet which is approximately 5 A.U. from the sun. Assume the solar constant on earth as 1400 W/m^2. [2]

Answer:

Using inverse square law, solar constant on the planet is

$$S = \frac{1400}{(5)^2}$$

$$= 56\ Wm^{-2}$$

Question: 12

Red light is incident on a thin converging lens of focal length 'f'. Briefly explain how the focal length of the lens will change, if red light is replaced with blue light. [2]

Answer:

$$\frac{1}{f} = (\mu - 1).\left(\frac{1}{R_1}.-\frac{1}{R_2}\right)$$

As, $\mu_B > \mu_R$, so focal length of the convex lens will decrease when blue light is used.

Question: 13

The thermo-emf of a thermocouple is given by the expression, $E = \alpha\theta - \beta\theta 2$, where '$\theta$' is the temperature of the hot junction. If $\alpha = 42\ \mu\ V^0C\text{-}1$, $\beta = 0.035\ \mu\ V^0C\text{-}2$, calculate the (i) neutral temperature and (ii) temperature of the inversion of the thermocouple, if the cold junction is at 20^0C.

Answer:

$E = \alpha\theta - \beta\theta 2$

$$\therefore \frac{dE}{d\theta} = \alpha - 2\beta\theta$$

$$\frac{dE}{d\theta} = 0$$

or $\alpha - 2\beta\theta = 0$

$$\theta_n = \frac{\alpha}{2\beta}$$

$$= \frac{42}{2 \times 0.035}$$

$$= 600^0C$$

$$\theta_i = \frac{\alpha}{\beta} - 20$$

$$= 1200 - 20$$

$$= 1180^0C$$

Question: 14

Sky waves are not used in transmitting TV signals. Why? State two factors by which the range of transmission of TV signals can be increased. [2]

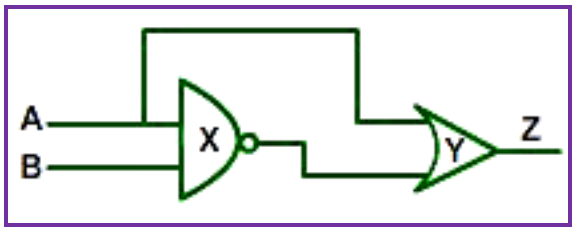
Answer:

TV signals have a frequency of 100 to 200 MHz which cannot be reflected by the ionosphere. So transmission of TV signals via sky wave is not possible. Range of TV transmission can be increased by using

i. tall antenna, and,
ii. geostationary satellites.

Question: 15

Identify the logic gates marked X, Y in the following figure. Write down the output at Z, when A = 1, B = 1 and A = 0, B = 1.



Answer:

Inputs		Output of NAND gate $Y = \overline{A+B}$	Output of OR gate Z = A + Y
A	B	0	1
1	1	0	0
0	1		

Question: 16

Calculate the current drawn by the primary of a transformer, which steps down 200 V to 20 V to operate a device of resistance 20Ω. Assume the efficiency of the transformer to be 80%.

Answer:

Current in secondary: $I_2 = \frac{V_2}{R} = \frac{20}{20} = 1\ A$

$$\text{Efficiency} = \frac{\text{Power output}}{\text{Power input}}$$

$$= \frac{V_2 . I_2}{V_1 . I_1}$$

$$= \frac{80}{100}$$

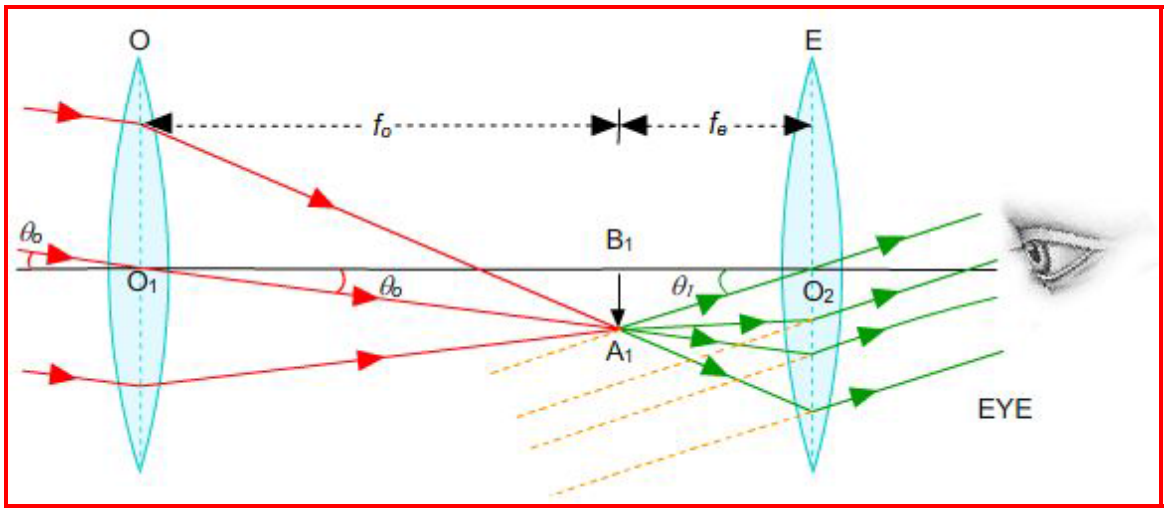
$$= \frac{20 \times 1}{200 \times I_1}$$

$$I_1 = \frac{20 \times 100}{200 \times 80}$$

Question: 17

Draw a ray diagram showing how the final image of a distant objects is formed using an astronomical telescope in the near point position. [3]

Answer:



Question: 18

State the condition for diffraction of light to occur. In the diffraction at a single slit experiment, how would the width and the intensity of central maximum change, if

i. slit width is halved and

ii. visible light of longer wavelength is used? [3]

Answer:

See topics on 'diffraction by a single slit'.

Diffraction of light occurs when size of the obstacle or the aperture is comparable to the wavelength of light.

Width of central maximum = $\frac{2D\lambda}{d}$

i. When slit width d is halved, central maximum width is doubled. Its area becomes 4 times and hence intensity becomes $\frac{1}{4}$ th the initial intensity.

ii. With visible light of longer wavelength, central maximum width increases and hence intensity decreases.

Question: 19

A semiconductor has equal electron and whole concentration of 2 x 10^8 / m^3. On doping with a certain impurity, the whole concentration increases to 4 x 10^{10} /m^3.

i. What type of semiconductor is obtained on doping?

ii. Calculate the new electron concentration of the semiconductor.

iii. How does the energy gap vary with doping? [3]

Answer:

i. As the hole concentration increases, the p-type semiconductor is obtained.

ii. As, $n_e n_h = n_i^2$

$\therefore n_e = \frac{n_i^2}{n_h}$

$$= \frac{(2 \times 10^8)^2}{4 \times 10^{10}}$$

$$= 10^6 / m^3$$

iii. Energy gap decreases with doping.

Question: 20

Draw the circuit diagram of a common-emitter amplifier, with appropriate biasing. What is the phase difference between the inputs the output signals? State two reasons why a common-emitter amplifier is preferred to a common base amplifier. [3]

Answer:

See topics on 'Transistors'.

In common-emitter amplifier, the phase difference between the input and output signals is 1800.

Common emitter amplifier has following advantages over a common-base amplifier

- High current gain
- High voltage gain

Question: 21

A parallel plate capacitor is charged to a potential difference 'V' by a DC source. The capacitor is then disconnected from the source. If the distance between the plates is doubled, state with reason how the following will change:

i. Electric field between the plates.
ii. Capacitance
iii. Energy stored in the capacitor. [3]

Answer:

The charge on the capacitor plates remain unchanged. So when distance d between the capacitor plates is doubled.

i. Electric field ($E = q / \varepsilon_0 A$) remains unchanged.
ii. Capacitance ($C = \varepsilon_0 A/d$) is halved.
iii. Energy stored ($U = q_2 / 2C$) is doubled.

Question: 22

Define 'electric potential'. Deduce an expression for the electric potential at a point distance 'r' from a point charge (Q>0) [3]

Answer:

Electric potential: It is defined as the amount of work done in bringing unit positive charge form infinity to the given point.

For derivation of expression for electric potential:

$$E = \frac{dv}{dr}, E = \frac{KQ}{r^2}$$

$$V = -\int_{\infty}^{r} E\,dr$$

$$= -\int_{\infty}^{r} \left[\frac{KQ}{r^2}\right] dr$$

$$V = \int_{\infty}^{r} \left[\frac{KQ}{r^2}\right]_{\infty}^{r}$$

$$= \frac{KQ}{r}$$

Question: 23

Define resistivity and state its S.I unit. State and explain how the resistivity of a conductor varies with temperature. [3]

Answer:

The resistivity of the material of a conductor is defined as the resistance of the unit length and unit area of cross-section of the conductor. The SI unit of resistivity is Ωm.

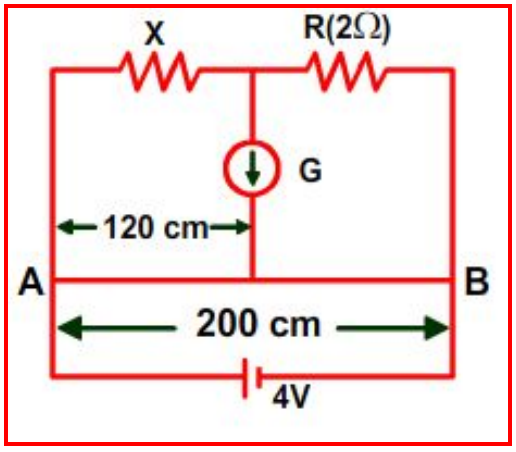
Resistivity of a conductor: $\frac{m}{ne^2\tau}$

With the increase of temperature, the amplitude of vibration of positive ions increases. The electrons suffer collisions more frequently. The relaxation time τ decreases. Hence the resistivity of a conductor increases with the increase in temperature.

Question: 24

Find the value of the unknown resistance X and the current drawn by the circuit from the battery, if no current flows through the galvanometer. Assume the resistance per unit length of the wire AB to 0.01 Ω/Cm. [3]

Answer:



Resistance of wire (AJ)
= 120 x 0.01 = 1.2Ω

Resistance of wire (BJ)
= 80 x 0.01 = 0.80 Ω

In the balanced condition,

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

$$\text{or, } \frac{1.2}{0.80} = \frac{X}{2}$$

$$\therefore X = \frac{1.2 \times 3}{0.80}$$

$= 3$

Total resistance of wire AB: 1.2 + 0.8 = 2Ω
Total resistance of X and R in series: 3 + 2 = 5Ω

The above two resistances are in parallel.

$$\therefore \text{Total resistance of the circuit: } \frac{2 \times 5}{2+5} = \frac{10}{7}\Omega$$

$$\text{Current, } I = \frac{\text{emf}}{\text{Resistance}}$$

$$= \frac{4}{\frac{10}{7}}$$

$= 2.8A$

Question: 25

The ground state energy of hydrogen atom is –13.6 eV. If an electron makes a transition form an energy level –0.85 eV to –3.4 eV, calculate the wavelength of the spectral lien emitted. To which series of hydrogen spectrum, does this wavelength belong? [3]

Answer:

Energy of emitted photon
$= -0.85 - (-3.4) = 2.55$ eV
$= 2.55 \times 1.6 \times 10^{-19}$ J

$$\text{As, } h\nu = \frac{hc}{\lambda}$$

$$= E_2 - E_1$$

$$\therefore \lambda = \frac{hc}{E_2 - E_1}$$

$$= \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{2.55 \times 1.6 \times 10^{-19}}$$

$= 4.853 \times 10\text{-}7$

$= 4853 \ \mathring{A}$

Question: 26

What are coherent sources of light? Deduce an expression for the intensity at any point on the screen in Young's double slit experiment. [5]

Answer:

Two sources which emit light waves of same frequency and in same phase or having a constant phase difference are called coherent sources.

Let the waves from two coherent sources be represented as

$y_1 = a \sin \omega t + b \sin (\omega t + \phi)$

Resultant displacement at the observation point is given by
$y = y_1 + y_2$
$= a \sin \omega t + b \sin (\omega t + \phi)$
$= a \sin a \sin \omega t + b \sin \omega t \cos \phi + b \cos \omega t \sin \phi$
$= (a + b \cos\phi) \sin \omega t + b \sin \phi \cos \omega t$

Put, $a + b \cos \phi = A \cos \theta$
and, $b \sin \phi = A \sin \phi$
they $y = A \cos \theta \sin \omega t + A \sin \theta \cos \omega t$
$= A \sin (\omega t + \theta)$

Thus the resultant wave is a harmonic wave of amplitude A.
Now, $A^2 (\cos^2\theta + \sin^2\theta)$
$= (a+b \cos\phi)^2 + (b \sin \phi)^2$

or, $A^2 = a^2 + b^2 + 2ab \cos \phi$

As intensity α (amplitude)^2, so resultant intensity is

$$\therefore I_R = I_1 + I_2 + 2\sqrt{I_1 I_2} \cos\phi$$

Question: 27 (**)

Prove that two parallel conductors of infinite lengths, carrying currents in the same direction attract each other. Deduce the expression for the force per unit length, experienced by each conductor [5]

Question: 28 (**) [5]

a. Define the terms decay constant and half-liters of a radioactive sample. Derive the relation connecting the two.
b. How many disintegrations per second will occur in one gram of $_{92}U^{238}$, if its half-liters against alpha decay are 1.42×10^{17}s?

Question: 29

Derive an expression for the self-inductance of a long solenoid. An inductor L, a capacitor 20μF, a resistor 10Ω are connected in series with an a.c source of frequency 50Hz. If the current is in phase with the voltage, calculate the inductor of the inductor.

Answer:
Consider a long solenoid of length l, number of turns N and radius r. suppose current I flows through it. Magnetic field set up in the coil is

$$B = \frac{\mu_0 NI}{l}$$

Flux through each turn $BA = \frac{\mu_0 NIA}{l}$

Total flux through N turns,

$$\phi = N \times \frac{\mu_0 NIA}{l} \times \frac{\mu_0 N^2 IA}{l}$$

But, $\phi = LI$

$$\therefore L = \frac{\phi}{I} = \frac{\mu_0 N^2 A}{l}$$

$$2\pi fL = \frac{1}{2\pi fC}$$

$$\therefore L = \frac{1}{4\pi^2 f^2 C}$$

$$= \frac{1}{4 \times 9.87 \times (50)^2 \times 20 \times 10^{-6}}$$

= 0.51 H

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