2013

Set: I

Set: I

Question: 1

What is the value of Seebeck coefficient at the neutral temperature of a thermocouple? [1]

Answer:
Zero

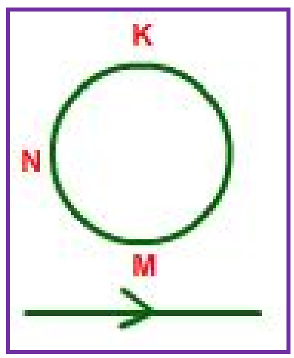
Question: 2

How does the drift velocity of electrons in a metallic conductor vary with increase in temperature? [1]

Answer:
Drift velocity of electrons in a metal conductor decreases as the temperature increases.

Question: 3

What is the magnitude of the induced current in the circular loop KLMN, radius 'f' if the straight wire PQ carries a steady current of magnitude 'i' ampere? [1]



Answer:
Zero

Question: 4

Arrange the given electromagnetic radiations in the descending order of their frequencies: Infra-red, X-rays, Ultraviolet and Gamma rays. [1]

Answer:
Gamma rays > X-rays > Ultraviolet > Infra – red

Question: 5

The refractive index of a medium is $\sqrt{3}$. What is the angle of refraction, if the unpolatised light is incident on it at the polarizing angle of the medium? [1]

Answer:
Here tan ip = $\mu = \sqrt{3}$
$\therefore$ ip = 60^0 and r = $90^0 - 60^0 = 30^0$

Question: 6

Calculate the length of the half wave dipole at 3000 MHz? [1]

Answer:

V = 3000 x 10^6Hz

$$\lambda = \frac{C}{V}$$

$$= \frac{3 x 108 m5^{-1}}{3000 x 106 s^{-1}}$$

$$= 0.1m$$

The, length of the dipole

= $\lambda/2$

= 0.05m

= 5cm.

Question: 7 (**)

What should be the height of geo-synchronous orbit from the surface of the earth? [1]

Question: 8

The frequency (v) of incident radiation is greater than threshold frequency (v_0) in a photocell. How will the stopping potential vary if frequency (v) is increased keeping other factors constant? [2]

Answer:

When v > v_0 stopping potential is directly proportional to frequency v.

Question: 9 (**)

Define angle of dip. Deduce the relation connecting angle of dip and horizontal component of earth's magnetic field at a place. [2]

Question: 10

Two point charges 3 x 10^{-8} C and –2 x 10^{-8} C are located at 15 cm apart in air. Find at what point on the line joining these charges the electric potential is zero. Take potential at infinity to be zero [2]

Answer:

Let the potential be zero at point O.

$\longleftarrow x \longrightarrow \quad \longleftarrow 0.15-x \longrightarrow$

Electic potential at O due to q_A:

$$V_A = 9 x 10^9 \; x \frac{3 x 10^{-8}}{x}$$

$$= \frac{270}{x}$$

Electric potential at O due to q_B:

$$V_B = 9 x 10^9 \; x \frac{(-2 x 10^{-}{}_{8})}{0.15 - x}$$

$$= -\frac{180}{0.15 - x}$$

But again, $V_A + V_B = 0$

$$\therefore \frac{270}{x} + \left(\frac{180}{0.15 - x}\right) = 0$$

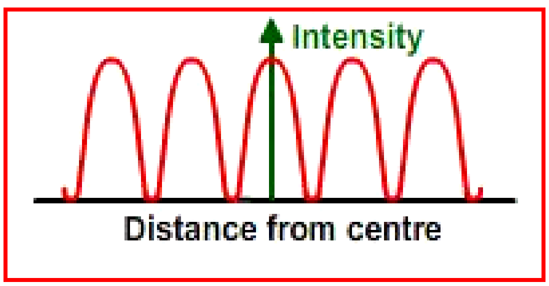
$$\text{or, } \frac{270}{x} = \frac{180}{0.15 - x}$$

or x = 0.09m = 9cm, from the charge of 3×10^{-8} C.

Question: 11

What are coherent sources of light? Draw the variation of intensity with position, in the interference pattern of Young's double slit experiment. [2]

Answer:
Two light sources are coherent if they emit light of same frequency and of zero or constant phase difference.



Question: 12

Two tangent galvanometers having equal radius of coils are connected in parallel to an electric cell. The ratio of the currents in the galvanometers is 1:2 and respective mean deflections are 30^0 and 45^0. Compare the ratio of the number of turns of the tangent galvanometers. [2]

Answer:

Given: $\frac{I_1}{I_2} = \frac{1}{2}$

or $2I_1 = I_2$

$$\text{or } \quad 2x\frac{2R_1H}{\mu_0 N_1}\tan\theta_1 = \frac{2R_1H}{\mu_0 N_2}\tan\theta_2$$

But $R_1 = R_2$

or, $\frac{N_1}{N_2}$

$$= \frac{2\tan\theta_1}{\tan\theta_2}$$

$$= \frac{2\tan 30^0}{\tan 45^0}$$

$= \frac{2 x 1}{1 x \sqrt{3}}$

$= 2 : \sqrt{3}$

Question: 13

Draw a labeled ray diagram showing the formation of image by a compound microscope. [2]

Answer:

See topics on 'Compound'.

Question: 14

Give reasons for the following observations made from Earth: [2]

i. Sun is visible before the actual sunrise.

Answer:

With altitude, the density and refractive index of air decreases. The light rays starting from the sun below the horizon bend more and more towards the normal. The sun appears in a position above the horizon. The sun appears two minutes before the actual sunrise.

ii. Sun looks reddish at sunset.

Answer:

At sunset, the rays from the sun have to travel a larger part of the atmosphere. As $\lambda_{blue} < \lambda_{red}$, and scattering intensity $\propto \frac{1}{\lambda^4}$, so most f the blue light is scattered away. Only red color comes from the sun. So the sun appears red.

Question: 15 (**)

Draw the energy band diagram of a p-type semiconductor. How does the forbidden gap of an intrinsic semiconductor vary with increase in temperature? [3]

Question: 16

Attenuation can be expressed in decibels (dB) according to equation 10 $\log_{10}\left(\frac{1}{1_0}\right)$, work out the aatenuation in dB per Km for a fiber in which the intensity falls by 50% over a distance of 50 Km. [3]

Answer:

Intensity levels of two waves of intensity I and I0 are defined to differ by B decibels.(dB).

Where $\beta = 10 \log_{10}\left(\frac{1}{1_0}\right)$,

When $I = 2I_0$, we have

$10 \log_{10}\left(\frac{2I_0}{I_0}\right)$

$= 10 \log_{10} 2$

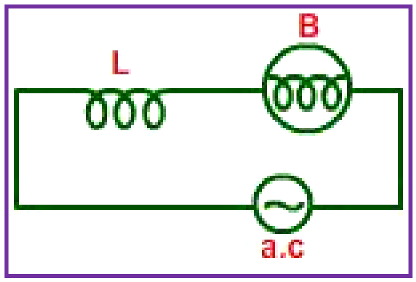
$= 3.01$

And their intensity levels differ by 3.01 dB at a distance of 50km.

$\beta = \frac{3.01}{50}$, dB per km.

Question: 17 [3]

An inductor 'L' of reactance X_L, is connected in series with a bulb 'B' to an AC source as shown in figure. Briefly explain how does the brightness of the bulb changes, when
i. Number of turns of the inductor is reduced
ii. A capacitor of reactance $X_C = X_L$ is included in series in the same circuit.



Answer:
i. When the number of turns of the inductor is reduced, its reactance decreases, so current in the circuit increases and brightness of the bulb increases.

ii. When, $X_L = X_C$, then impedence Z = $\sqrt{R^2 + (XL - XC)^2} = R$ becomes minimum. Current in the circuit is maximum. Bulb glows with maximum brightness.

Question: 18

Define the S.I unit of magnetic field. "A charge moving at right angles to a uniform magnetic field does not undergo change in kinetic energy." Why? [3]

Answer:
Tesla is the SI unit of magnetic field. The magnetic field at a point is Tesla if a charge of one Coulomb while moving perpendicular to the magnetic field with velocity of $1 ms^{-1}$ experiences a force of 1 newton at that point.

The force on moving charged particle in a magnetic field is perpendicular to its direction of motion. So work done on the charged particle by the magnetic force is zero. Here the kinetic energy of a charged particle in a magnetic field remains unchanged.

Question: 19 [3]

A battery of e.m.f 'E", and internal resistance 'r', gives a current of 0.5A with an external resistor of 12 ohm and a current of 0.25 A with an external resistor of 25 ohm. Calculate,
i. Internal resistance of the cell
ii. e.m.f of the cell.

Answer:
E = I (R + r)
In first case:
E = 0.5 (12 + r)

In second case:
$E = 0.25\ (25 + r)$
$\therefore\ 0.5\ (12 + r)$
$= 0.25\ (25 + r)$

On solving:
$r = 1\Omega$
$\therefore\ E = 0.5\ (12 + 1)$
$= 6.5$ V

Question: 20

Define the term ‘electric dipole moment’. Give its unit. Derive an expression for the maximum torque acting on an electric dipole, when held in a uniform electric field. [3]

Answer:
Electric dipole moment of an electric dipole is equal to the product of either charge q and the separation between the two charges $\left(2\vec{a}\right)$.

Thus, $\vec{p} = q \times \left(2\vec{a}\right)$

The direction of $\vec{p}$ is from negative charge to positive charge.

For expression of torque as, $\tau = pE \sin\theta$

Clearly torque will be maximum when $\theta = 90^0$. Then, $\tau_{max} = pE$

Question: 21

Why the base region of a transistor is usually made thin? In a common-emitter mode of transistor, DC current gain is 20; the emitter current is 7 mA. Calculate (i) base current and (ii) collector current. [3]

Answer: ’
This reduces the recombination rate of electrons and holes in the base region and most of the majority carriers go from emitter to collector to provide sufficient collector current.

Numerical:

$$\alpha_{dc} = \frac{\beta_{dc}}{1+\beta_{dc}}$$

$$= \frac{20}{1+20}$$

$$= \frac{20}{21}$$

$$= \frac{I_C}{I_E}$$

$$\text{or, } I_C = \frac{20}{21} \times I_E$$

$$= \frac{20}{21} \times 7$$

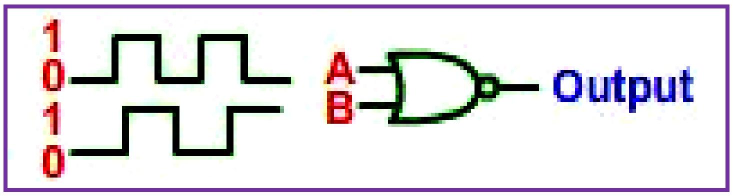
$= \frac{20}{3}$

$= 6.67\,mA$

$I_B = I_E - I_C$
$= 7 - 6.67$
$= 0.33$ mA

Question: 22

In the figure, circuit symbol of logic gate and input wave forms are given. Name the logic gate. Write its truth table and give the output wave form. [3]



Answer:
See topics on 'NOR gate'.

Question: 23

Two lenses of powers +15 D and –5 D are in contact with each other forming a combination lens.
a. What is the focal length of this combination?
b. An object of size 3 cm is placed at 30 cm from this combination of lenses. Calculate the position and size of the image formed. [3]

Answer:
Power of combination:
$P_1 + P_2$
$= 15 - 5$
$= 10$ D

a. Focal length of combination (f): $\frac{1}{P} = \frac{1}{10m} = 10cm$

b. Given, $h_1 = 3$ cm, $u = -30$cm

Using thin lens formula, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

or, $\frac{1}{v} = \frac{1}{f} + \frac{1}{u}$

$= \frac{1}{10} - \frac{1}{30}$

$= \frac{1}{15}$

or, $v = +15$ cm

$m = \frac{h_2}{h_1} = \frac{v}{u}$

$$h_2 = \frac{v}{u} x h_1$$
$$= \frac{15}{-30} x 3$$
$$= -1.5cm$$

Real inverted image of size 1.5 cm is formed at 15cm on the other side of the combination.

Question: 24

Explain the principle of Whaeatstone Bridge for determining an unknown resistance. How is it realized in actual practice in the laboratory? [3]

Answer:
See topics on 'Wheatstone and Metre Bridge'.

Question: 25 [3]

Why is diffraction of sound waves more easily observed than diffraction of light waves? Light of wavelength 600 nm is incident on a single slit of width 0.5 mm at normal incidence.

Calculate the separation between two dark bands on either side of the central maximum, if the diffraction pattern is observed on a screen placed at 2m from the slit.

OR

With the help of relevant diagrams, explain the following terms:
(i) Pulse-position modulation (PPM)
(ii) Pulse-duration modulation (PPM)

Answer:
For diffraction of a wave, an obstacle of the size of wavelength of the wave is needed. As wavelength of light is of the order of 10-6m, and obstacles of this size are rare, obstacles of this size are common, so diffraction of sound is common.

Numerical:
Separation between dark bands on either side of central maximum = width of central maximum

$$\beta_0 = \frac{2D\lambda}{d}$$
$$= \frac{2 x 2 x 6000 x 10^{-10}}{0.5 x 10 - 3}$$
$$= 4.8 x 10^{-3} m$$
$$= 4.8 mm$$

Question: 26

'The half-life of C $^{14}_{6}C$ is 5700 years. What does it mean? Two radioactive nuclei X and Y initially contain an equal number of atoms. Their half-life is 1 hour and 2 hours respectively. Calculate the ratio of their rates of disintegration after two hours. [3]

Answer:

The half-life of $^{14}_{6}C$ is 5700 years. It means that one half the present number of radioactive nuclei will remain un-decayed after 5700 years.

Let both X and Y have N atoms each initially.

No. of nuclei of X left un-decayed after 1h: $\frac{N}{2}$

No. of nuclei of X left un-decayed after 2h: $\frac{1}{2} x \frac{N}{2} = \frac{N}{4}$

No. of nuclei of Y left un-decayed after 2h: $\frac{N}{2}$

Ratio of the rates of disintegration after 2 hours: $\frac{\frac{N}{4}}{\frac{N}{2}} = \frac{1}{2} = 1:2$

Question: 27

Find the equivalent capacitance of the combination of capacitors between the points A and B as shown in the figure. Also calculate the total charge that flows in the circuit when a 100 V battery is connected between the points A and B. [5]

Answer:

Clearly, three capacitor of 60 μF each are in parallel. Their equivalent capacitance is

Their equivalent capacitance C_1 is given by

$$\frac{1}{C_1} = \frac{1}{60} + \frac{1}{60} + \frac{1}{60} = \frac{3}{60} = \frac{1}{20}$$

or, C_1 = 20 μF

Also two capacitors of 10 μF are in parallel. Their equivalent capacitance is

C_2 = 10 + 10

= 20 μF

Now combinations C_1 and C_2 are mutually parallel. Their combined capacitance is

$C_3 = C_1 + C_2$

= 20 + 20

= 40 μF

Finally, we have two 40 μF capacitors connected in series between A and B. so equivalent capacitance between A and B is given by

$$\frac{1}{C} = \frac{1}{40} + \frac{1}{60} = \frac{1}{20}$$

or, C = 20 μF

Charge, Q = CV

= 20 x 10-6 x 100

= 2 x 10-4 C

Question: 28 [5]

Draw a labeled diagram of an AC generator. Write the principle on which it works. An AC generator consists of a coil of 100 turns and cross-sectional area of $3m^2$, rotating at a constant angular speed of 60 radians/sec in a uniform magnetic field of 0.04 T.

The resistance of the coil is 500 ohm. Calculate
i. Maximum current drawn from the generator
ii. Maximum power dissipation in the coil.

Answer:
See topics on 'A.C generator'.
Numerical:

Here N = 100, A = 3m2, w = 60 rad/s, B = 0.04 T, R = 500Ω

i. Maximum current (I_o):

$$= \frac{E_o}{R}$$

$$= \frac{NBAW}{R}$$

$$= \frac{100 \times 0.04 \times 3 \times 60}{500}$$

$$= 1.44A$$

ii. Power loss = $E_{eff}.\ I_{eff}$

$$\frac{E_o I_o}{2} = \frac{I_o^2 R}{2}$$

$$= \frac{(1.44)^2 \times 500}{2}$$

$$= 518.4 \text{ W}$$

OR

With the help of a labeled diagram, explain the working principle of a step-up transformer. In an ideal transformer, number of turns in the primary and secondary are 200 and 1000 respectively.

If the power input to the primary is 10 kW at 200 V, calculate,
i. Output voltage
ii. Current in primary.

Answer:
See topics on 'Theory'

Here, N_1 = 200, N_2 = 1000, V_1 = 200 V, P_1 = 10 kW = 10000 W

i. $$\frac{N_2}{N_1} = \frac{V_2}{V_1}$$

$$V_2 = \frac{N_2}{N_1} \times V_1$$

$= \frac{1000}{20} x 200$

$= 1000V$

ii. Input power:

$P_1 = I_1 . V_1$

$\therefore I_1 = \frac{P_1}{V_1}$

$= \frac{10,000}{200}$

$= 50A$

Question: 29

State Biot-Savart law. Using Biot-Savart law, derive an expression for the magnetic field at the centre of a circular coil of number of turns 'N', 'r' carrying a current 'i'. A semi-circular arc of radius 20 cm carries a current of 10 A.

Calculate the magnitude of the magnetic field at the centre of the arc. [5]

Answer:
See topics on 'Biot-Savart law'.

Numerical:
Given, r = 20cm = 0.20m, and, I = 10V

Magnetic field at the center of semicircular arc:

$B = \frac{\mu_o I}{4r}$

$= \frac{4r x 10^{-7} x 10}{4 x 0.20}$

$= 1.57 x 10^{-5} T$

Question: 30

Draw the graph to show variation of binding energy per nucleon with mass number of different nuclei. [5]

Answer:
See topics on' Mass defect'.

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