
2012

Set: I

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Question: 1

Give reason to show that microwaves are better carriers of signals for long range transmission than radio waves. [3]

Answer:

Due to then smaller wavelength, microwaves can be transmitted as beam signals in a particular direction, much better than radiowaves because microwaves do not bend around the corners of any obstacle coming in their path.

Question: 2

How does the energy gap in an intrinsic semiconductor vary, when dropped with a pentavalent impurity? [3]

Answer:

Energy gap becomes smaller.

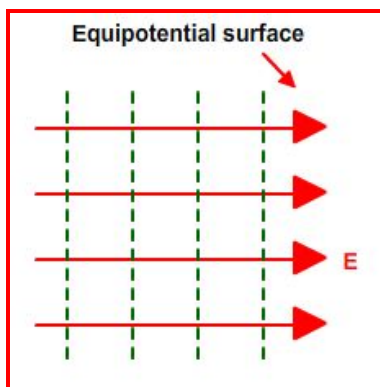
Question: 3 ()**

State the condition in which terminal voltage across a secondary cell in. [1]

Question: 4

Draw an equipotential surface in a uniform electric field. [1]

Answer:



Question: 5

If the number of turns of a solenoid is doubled, keeping the other factors constants, how does the self-inductance of the solenoid change? [1]

Answer:

Self inductance increases four times because $L \propto N^2$.

Question: 6 ()**

What will happen to the image formed by a mirror if half of it is covered with a black paper? [1]



Question: 7 ()**

Does sound like light is passing from air to water also bend towards the normal?

[1]

Question: 8

What is the angle of dip at a place where the horizontal and vertical components of earth's magnetic field are equal?

[2]

Answer:

$$\tan \delta = \frac{B_V}{B_H} = 1$$

$$\therefore \delta = 45^\circ$$

Question: 9

A positive charge Q is distributed uniformly over a thin wire of radius R. Write the final relation of the intensity of the electric field at a point on the axis of the ring at a distance X from its centre. At what points on the axis of the ring the intensity is maximum.

[2]

Answer:

$$E = \frac{1}{4\pi\epsilon_0} \cdot \frac{q x}{(a^2 + x^2)^{3/2}}$$

$$x = \pm \frac{R}{\sqrt{2}}$$

Question: 10

Using Gauss's law, show that no electric field intensity exists inside a hollow charged conductor.

[2]

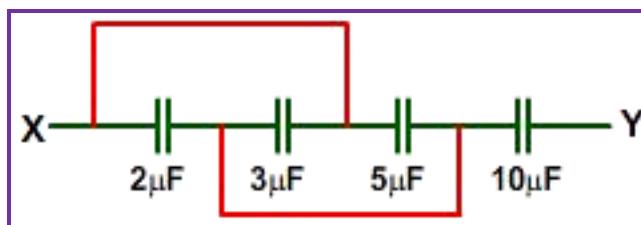
Answer:

Consider a charged conductor with a cavity inside it. Take a Gaussian surface inside the conductor near the cavity $E = 0$, everywhere inside the conductor. By Gauss's law, charge enclosed by the Gaussian surface is zero. Hence electric field must be zero at all point inside the cavity.

Question: 11

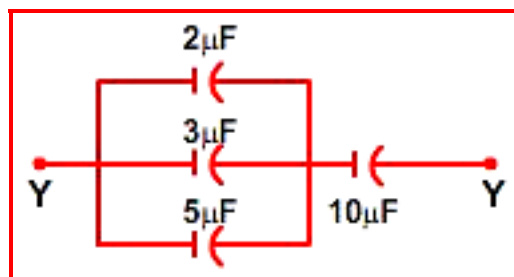
[2]

Four capacitors are connected as shown in the figure given below. Calculate the equivalent capacitance between the points X and Y.



Answer:





The given network is equivalent to the following circuit:

Clearly, $2\mu\text{F}$, $3\mu\text{F}$ and $5\mu\text{F}$ capacitors are in parallel.

Their equivalent capacitance: $2 + 3 + 5 = 10\mu\text{F}$

Then, we get a series combination of two $10\mu\text{F}$ capacitors.

Hence equivalent capacitance between X and Y,

$$= \frac{10 \times 10}{10 + 10}$$

$$= 5\mu\text{F}$$

Question: 12

Draw the graph showing the variation of binding energy per nucleon with the mass number of different nuclei. State two interferences from this graph. [2]

Answer:

See topics on 'mass defect'.

Question: 13

In a single slit diffraction experiment, if the width of the slit is doubled, how does the (i) intensity of light and (ii) width of the central maximum change. Give reason for your answer. [2]

Answer:

See topics on 'Single slit diffraction'

Question: 14

Draw the logic symbol of a 2-input NAND gate. Write down its truth table. [2]

Answer:

See topics on 'NAND gate'.

Question: 15

A ray of light passes through an equilateral glass prism, such that the angle of incidence is equal to the angle of emergence. If the angle of emergence is $\frac{3}{4}$ times the angle of the prism, calculate the refractive index of the glass prism. [3]

Answer:



See topics on 'Prism'.

Question: 16

Calculate the equivalent capacitance between P and Q.

[3]

Answer:

All the three capacitors C_1 , C_2 and C_3 are in parallel.

$$C = C_1 + C_2 + C_3$$

Question: 17 ()**

A rectangular coil of N turns and area of cross-section A , is held in a time-varying magnetic field given by $B = B_0 \sin \omega t$, with the plane of the coil normal to the magnetic field. Deduce an expression for the e.m.f. induced in the coil.

[3]

Question: 18 ()**

Draw the graph showing variation of thermo e.m.f of a thermo-couple with the temperature difference of its junctions. How does its neutral temperature vary with the temperature of the cold junction?

[3]

Question: 19

Derive an expression for the electric potential at a point along the axial line of an electric dipole.

[3]

Answer:

See topics on 'Torque'.

Question: 20

A copper voltmeter is in series with a heater coil of resistance 0.1 ohm . A steady current flow in the circuit for 20 minutes, and a mass of 0.99 gm of copper deposited at the cathodic. If the electro-chemical equivalent of copper is $0.00033 \text{ gm coulomb}$, calculate the heat generated in the coil.

[3]

Answer:

$$Z = 0.00033 \text{ g C-},$$

$$R = 0.1 \Omega,$$

$$t = 20 \text{ min} = 1200 \text{ s},$$

$$m = 0.99 \text{ g}$$

$$I = \frac{m}{zt}$$

$$= \frac{0.99}{0.00033 \times 1200}$$

$$= 2.5 \text{ A}$$

$$\text{Heat produced: } I^2 R t$$

$$= (2.5)^2 \times 0.1 \times 1200$$

$$= 750 \text{ J}$$



Question: 21

State Huygen's postulates of wave theory. Sketch the wave front emerging from a,

- point source of light and
- linear source of light like a slit.

[3]

Answer:

Postulates of Huygen's wave theory are

- Every point on the given wave front acts a fresh source of new disturbance called secondary wavelets which travel in all directions with the speed of light.
- A surface touching these secondary wavelets, tangentially in the forward direction at any instant gives the new wave front at that instant.'

Question: 22

State the conditions for total internal reflection of light to take place at an interface separating two transparent media. Hence derive the expression for the critical angle in terms of the speeds of light in the two media.

[3]

Answer:

Conditions for total internal reflection are:

- Light should travel from a denser medium to a rarer medium.
- Angle of incidence in denser medium should be greater than the critical angle for the pair of media in contact.

Question: 23

State the dependence of work function on the kinetic energy of electron emitted in a photocell. If the intensity of incident radiation is doubled, what changes occur in the stopping potential and the photoelectric current?

[3]

Answer:

According to Einstein's theory of photoelectric effect, kinetic energy of emitted electron is greater the work function of the metal, the lesser is the kinetic energy of the photoelectron. On doubling the intensity of the incident radiation, stopping potential remains same whereas photoelectric current is doubled.

Question: 24

With the help of a labeled circuit diagram, explain how you will determine the internal resistance of a primary cell using a potentiometer. State the formula used.

[3]

Answer:

See topics on 'Potentiometer'.

Question: 25

A short bar magnet of magnetic moment 0.9 joule/tesla, is placed with its axis at 45° to a uniform magnetic field. If it experiences a torque of 0.063 joule, (i) calculate the magnitude of the magnetic field and (ii) what orientation of the bar magnet corresponds to the stable condition in the magnetic field.

[3]



Answer:

Here, $m = 0.9 \text{ JT}^{-1}$, $\theta = 45^\circ$, $\tau = 0.063 \text{ J}$

i. As $\tau = mB \sin\theta$

$$\begin{aligned}\therefore B &= \frac{\tau}{m \sin\theta} \\ &= \frac{0.063}{0.9 \times \sin 45^\circ} \\ &= 0.999 \text{ T}\end{aligned}$$

ii. The bar magnet will be in stable equilibrium when its magnetic moment is parallel to the magnetic field. I'.

Question: 26

A conductor of length 'l' is connected to a DC source of potential 'V'. If the length of the conductor is tripled, by stretching it, keeping 'V' constant, explain how the following factors vary in the conductor: (i) Drift speed of electrons, (ii) Resistance and (iii) Resistivity. [3]

Answer:

$$\text{Drift speed, } v_d = \frac{eV}{ml} \cdot \tau$$

$$\text{Resistance, } R = \rho \cdot \frac{l}{A}$$

When l is tripled

- Drift-speed becomes 1/3 times the original v_d .
- Resistance becomes 3 times the original resistance.
- Resistivity is not affected.

Question: 27

A proton and an alpha particle of the same velocity enter in turn a region of uniform magnetic field acting in a plane perpendicular to the magnetic field. Deduce the ratio of the radii of the circular paths described by the particles.

Explain why the kinetic energy of the particle after emerging from the magnetic field remains unaltered. [5]

Answer:

$$\begin{aligned}r &= \frac{mV}{qB} \\ \therefore \frac{r_p}{r_\alpha} &\times \frac{q_\alpha}{q_p}\end{aligned}$$

But $m_\alpha = 4m_p$, $q_\alpha = 2q_p$

$$\begin{aligned}\therefore \frac{r_p}{r_\alpha} &= \frac{m_p}{4m_p} \times \frac{2q_p}{q_p} \\ &= \frac{1}{2}\end{aligned}$$



$$= \frac{1}{2}$$

$$= 1:2$$

Question: 28

- a. A potential difference V is applied to a copper wire of diameter d and length L . what is the effect on the electron drift speed of doubling (i) Voltage V (ii) Length (iii) diameter.

Answer:

According to 'electron theory of metals' the drift speed of an electron inside a metal in presence of an electric field E is,

$$V_d = \frac{eV\tau}{mL}$$

- As $V_d \propto V$, on doubling V , drift velocity will be doubled.
 - $V_d \propto (1/L)$ on doubling L , drift velocity will be halved.
 - As drift velocity is independent of diameter d , it will not change on doubling the diameter.
- b. An n-type silicon sample of width 4×10^{-3} thickness 25×10^{-5} and length 6×10^{-2} m, carries a current of 4.8 mA when the voltage is applied across the length of the sample. What is the current density? If the free e- density is 10^{22} m^{-3} , then find how much time does it take for the electron to travel the full-length of the sample? [5]

Answer:

$$J = \frac{i}{A}$$

$$= \frac{i}{(B \times d)}$$

$$= \frac{4.8 \times 10^{-3}}{(25 \times 10^{-5}) \times (4 \times 10^{-3})}$$

$$= 4.8 \times 10^{-3} \frac{\text{A}}{\text{m}^2}$$

$$J = neV_d \quad V_d = \frac{J}{ne}$$

Question: 29

For a given AC circuit, distinguish between resistance, reactance and impedance. An AC source of frequency 50 hertz is connected to a 50 m H inductor and a bulb. The bulb glows with some brightness.

Calculate the capacitance of the capacitor to be connected in series with the circuit, so that the bulb glows with maximum brightness. [3+2]

Answer:

Resistance:

The property due to which a conductor resists the flow of electrons through it is called resistance of the conductor. It is measured by the ratio of the potential difference between the ends of the



conductor to the current flowing through it. If an alternating current is passed through a resistor, the current and voltage are in the same phase.

Reactance

The opposition offered by an inductor or a capacitor to the flow of AC through it is called reactance.

Impedance

The total opposition offered by L, C, R circuit to the flow of alternating current is called impedance.

Numerical

Given, $f = 50 \text{ Hz}$, $L = 50 \text{ mH} = 50 \times 10^{-3} \text{ H}$

When the LC circuit is in resonance, the bulb will glow with maximum brightness.

Then,

$$X_L = X_C$$

$$\text{or, } 2\pi fL = \frac{1}{2\pi fC}$$

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

$$= \frac{1}{4 \times 9.87 \times (50)^2 \times 50 \times 10^{-3}}$$

$$= 8.11 \times 10^{-4} \text{ F}$$

Question: 30

Drawing a labeled circuit diagram, explain the working principle of a common emitter transistor amplifier. State the phase relation between input and output signals. [5]

Answer:

See topics on 'Common emitter'.

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

