
2008

Set: I

Question: 1 – 30

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Question: 1

Name the part of the electromagnetic spectrum of wavelength 102 m and mention its one application. [3]

Answer:

Radio waves; radio signals like AM radio

Question: 2

An electron and alpha particle have the same kinetic energy. How is the de-Broglie wavelengths associated with them related? [3]

Answer:

$$\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mE}}$$

$$\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{m_2 E_2}{m_1 E_1}} = \sqrt{\frac{m_2}{m_1}}$$

$$\frac{\lambda_a}{\lambda_e} = \sqrt{\frac{m_a}{m_e}} = \sqrt{\frac{4m_p}{m_e}}$$

Masses are given in question paper, substitute values and calculate.

Question: 3

A converging lens of refractive index 1.5 is kept in a liquid medium having same refractive index. What would be the focal length of the lens in this medium? [1]

Answer:

Infinite

$$\frac{1}{f} = \frac{n_2 - n_1}{n_1} \cdot \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$$

$$\frac{1}{f} = 0, \text{ as, } n_2 = n_1 \text{ (f is infinite)}$$

Question: 4

A 500 mC charge is at the centre of a square of side 10 cm. Find the work done in moving a charge of 10 m C between two diagonally opposite points on the square [1]

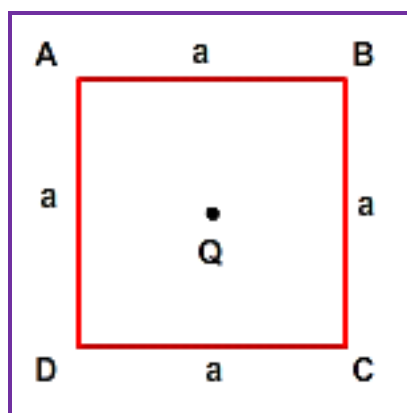
Answer:

Work done is $q(V_2 - V_1)$. As potential at the two diagonally opposite points is same work done will be zero.

Question: 5

The plot of the variation of potential difference across a combination of three identical cells in series, versus current is as shown below. What is the emf of each cell? [1]





Answer:

$$\varepsilon = V - IR$$

When, $I = 0$, then, $\varepsilon = V$

$$\varepsilon = 6V$$

emf of each cell is 2V

Question: 6

How does the angular separation of interference fringes change, in Young's experiment, if the distance between the slits is increased? [1]

Answer:

$\theta = \frac{\lambda}{d}$; so, if d is increased then angular separation will decrease.

Question: 7

What is the direction of the force acting on a charged particle q , moving with a velocity in a uniform magnetic field? [1]

Answer:

F is perpendicular to both velocity vector and magnetic field vector.

Question: 8

State the reason, why heavy water is generally used as a moderator in a nuclear reactor. [2]

Answer:

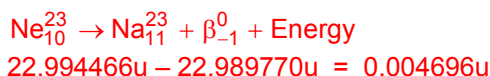
It helps to slow down the neutrons so that the probability of their participating in a nuclear reaction increases. Since heavy water has a mass that is comparable with neutrons they are effective in slowing down the neutrons.

Question: 9

A nucleus ${}^{23}_{10}\text{Ne}$ undergoes β -decay and becomes, ${}^{23}_{11}\text{Na}$. Calculate the maximum kinetic energy of electrons emitted assuming that the daughter nucleus and anti-neutrino carry negligible kinetic energy. [2]



Answer:



Energy is:
 $0.004696\text{u} \times 931.5 \text{ MeV}$
 $= 4.374 \text{ MeV}$

Question: 10

Distinguish between an intrinsic semiconductor and P-type semiconductor. Give reason, why a P-type semiconductor crystal is electrically neutral, although $n_h > n_e$? [2]

Answer:

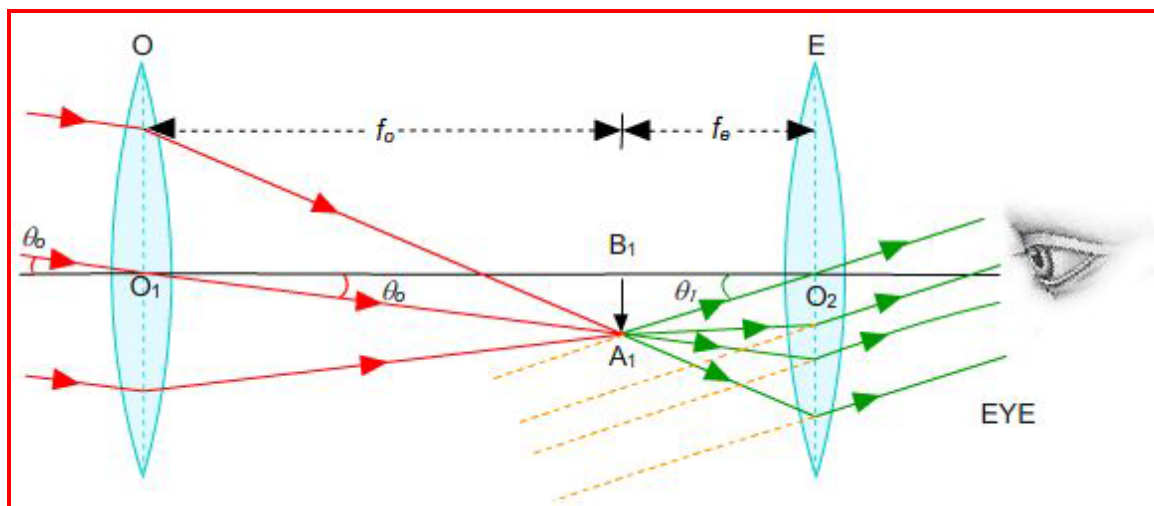
An intrinsic semiconductor has a few free electrons and an equal number of holes. Its conductivity is temperature dependant and increases with an increase in temperature. A p-type semiconductor is doped with an element from the 3rd group to increase its conductivity.

So the number of holes in this semiconductor is much larger than the number of electrons. It is electrically neutral, as charged particles are not added to make the semiconductor p-type. When a semiconductor is doped, atoms are added to it and then no charges are removed or added. So they cannot make the material charged.

Question: 11

Draw a ray diagram of an astronomical telescope in the normal adjustment position. State two drawbacks of this type of telescope. [2]

Answer:



Drawbacks

- Limit to its resolving power which means the smallest distance between objects that can be clearly seen.
- Spherical aberration and chromatic aberration occurs in its lenses.



Question: 12

Calculate the distance of an object of height h from a concave mirror of focal length 10 cm, so as to obtain a real image of magnification 2.

Answer:

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

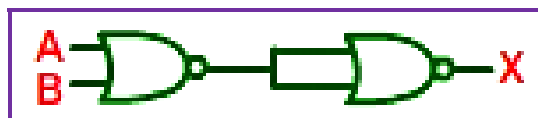
$$\frac{1}{f} = \frac{1}{2u} + \frac{1}{u}$$

$$\frac{1}{f} = \frac{3}{2u}$$

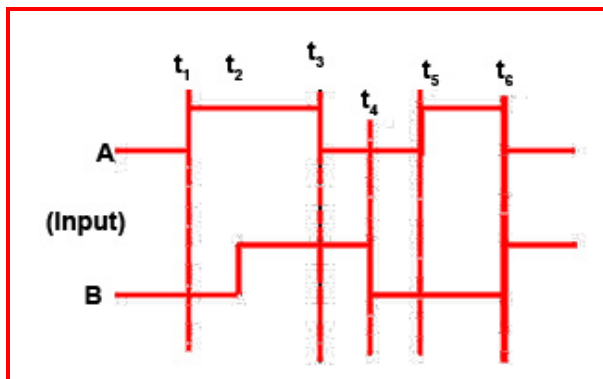
$$f = -10$$

Question: 13

Draw the output wave form at X, using the given inputs A, B for the logic circuit shown below. Also identify the gate.



Answer:



A	B	X
1	0	0
1	1	1
0	1	0
0	0	0
1	0	0

Question: 14

A transmitting antenna at the top of a tower has a height of 36 m and the height of the receiving antenna is 49 m. What is the maximum distance between them, for satisfactory communication in the LOS mode? (Radius of earth = 6400 km) [2]

Answer:

$$\sqrt{2hR_T} + \sqrt{2hR_R}$$



$$\begin{aligned}
 &= \sqrt{2 \times 6400 \times 1000 \times 36\text{m}} + \sqrt{2 \times 6400 \times 49\text{m}} \\
 &= 21.4 \text{ Km} + 25.3 \text{ Km} \\
 &= 46.7 \text{ Km}
 \end{aligned}$$

Question: 15

Derive an expression for the potential energy of an electric dipole of the dipole moment in an electric field [3]

Answer:

$$\begin{aligned}
 U &= \int \tau \cdot d\theta \\
 U &= \int pE \sin \theta d\theta \\
 &= [pE \cos \theta]_{90}^0 \\
 &= -pE \cos \theta \\
 &= -\vec{p} \cdot \vec{E}
 \end{aligned}$$

Question: 16

Define magnetic susceptibility of a material. Name two elements, one having positive Susceptibility and the other having negative susceptibility. What does negative susceptibility signify? [3]

Answer:

$M = \chi H$ where M is the magnetization of the material and H is magnetic intensity. It is a measure of how a material behaves in an external field. Paramagnetic and ferromagnetic substances example iron have positive susceptibility and diamagnetic substances example copper have negative susceptibility.

Question: 17

What is the value of Seebeck coefficient at the neutral temperature of a thermocouple? [3]

Answer:

$$S = \frac{dE}{dt} = 0 \text{ at } t = t_n$$

Question: 18

Distinguish between diamagnetic and ferromagnetic materials in respect of their (i) intensity of magnetisation, (ii) behaviour in a non-uniform magnetic field and (iii) susceptibility. [3]

Answer:

See topics on 'Magnetic materials'.

Question: 19 ()**

Prove that the current density of a metallic conductor is directly proportional to the drift speed of electrons.

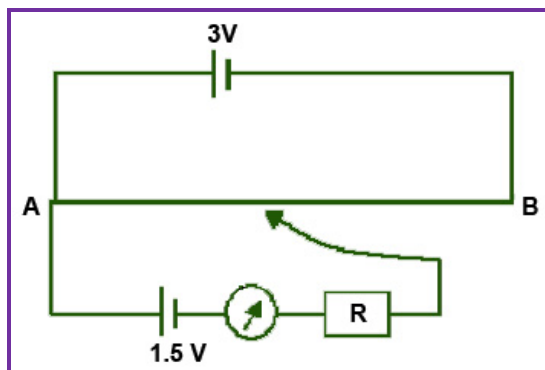
OR



Define conductivity of a conductor. Explain the variation of conductivity with temperature in (a) good conductors (b) ionic conductors.

Question: 20

A potentiometer wire of length 1m is connected to a driver cell of emf 3V as shown in the figure. When cell of 1.5 V emf is used in the secondary circuit, the balance point is found to be 60 cm. On replacing this cell and using a cell of unknown emf, the balance point shifts to 80 cm. [3]



Answer:

$$\frac{\varepsilon_1}{\varepsilon_2} = \frac{l_1}{l_2}$$

$$\frac{1.5}{x} = \frac{60}{80}$$

- No, a balance point will not be reached and current will flow for all positions of the jockey.
- No, it does not affect the balance point as at balance, as the current through the circuit with R is zero at balance.

Question: 21

An electromagnetic wave of wavelength λ is incident on a photosensitive surface of negligible work function. If the photo-electrons emitted from this surface have the deBroglie wavelength λ_1 , prove that $\lambda = \left(\frac{2mc}{h} \right) \lambda_1^2$ [3]

Answer:

$$E = h \cdot \frac{c}{\lambda} - h \cdot \frac{c}{\lambda_0}$$

$$E = h \cdot \frac{c}{\lambda}$$

$$p = \sqrt{2mE}$$

$$= \sqrt{2mh \frac{c}{\lambda}}$$

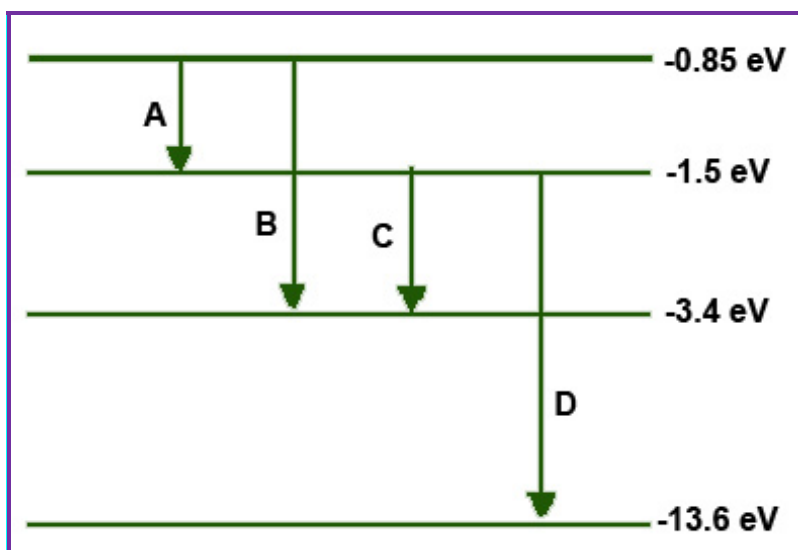
$$\lambda_1 = \frac{h}{p}$$



$$= \frac{h}{\sqrt{2mh \frac{c}{\lambda}}}$$

Question: 22

The energy level diagram of an element is given below. Identify, by doing necessary calculations, which transition corresponds to the emission of a spectral line of wavelength 102.7 nm. [3]



Answer:

$$h\nu = E_1 - E_2$$

Now, $E_1 - E_2$

$$= h \cdot \frac{c}{\lambda}$$

$$= \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{102.7 \times 10^{-9}} \text{ J}$$

$$= \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{102.7 \times 10^{-9} \times 1.6 \times 10^{-19}} \text{ eV}$$

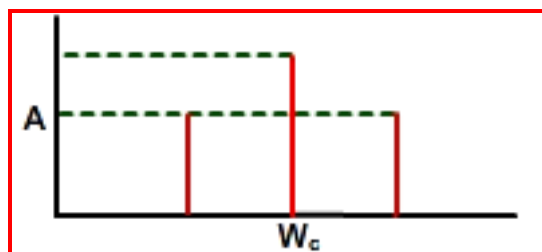
$$= 12 \text{ eV}$$

Question: 23

Draw a plot of the variation of amplitude versus w for an amplitude modulated wave. Define modulation index. State its importance for effective amplitude modulation. [3]



Answer:



Amplitude of side band : $\frac{\mu A_i}{2}$

Modulation index = $\frac{\text{Amplitude of message signal}}{\text{Amplitude of carrier wave}}$

In practice this is kept less than 1 to avoid distortion.

Question: 24

How is a wave front defined? Using Huygen's construction draw a figure showing the propagation of a plane wave reflecting at the interface of the two media. Show that the angle of incidence is equal to the angle of reflection. (**) [3]

Question: 25

A coil of number of turn's N, area A, is rotated at a constant angular speed ω , in a uniform magnetic field B, and connected to a resistor R. Deduce expressions for:

- Maximum emf induced in the coil
- Power dissipation in the coil

Answer:

$$\varepsilon = -\frac{d\phi}{dt}$$

$$\phi = NBA \cos \theta = NBA \cos \omega t$$

$$\varepsilon = -\frac{d\phi}{dt} = NBA \omega \sin \omega t$$

$$\text{Maximum } E = NBA \omega$$

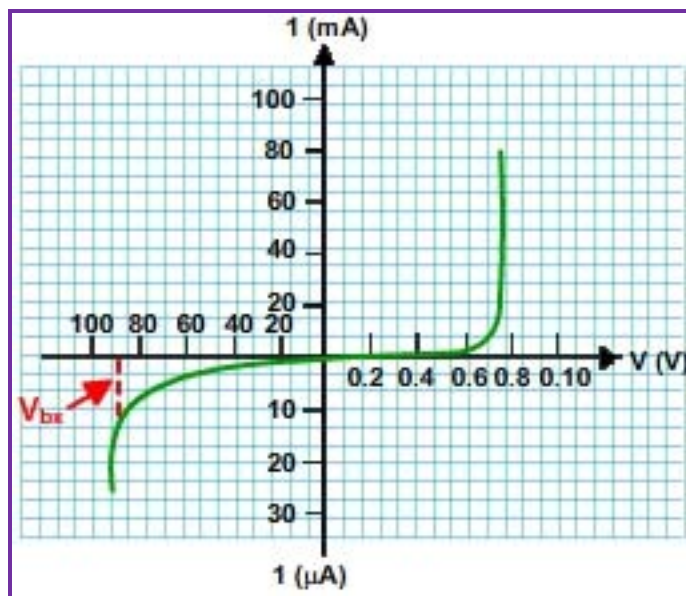
Power:

$$\begin{aligned} I^2 R &= \frac{V^2}{R} \\ &= \frac{(NBA \omega)^2}{R} \end{aligned}$$

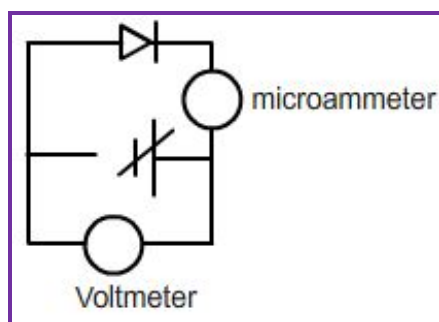
Question: 26 ()**

The figure below shows the V-I characteristic of a semiconductor diode





- Identify the semiconductor diode used.
- Draw the circuit diagram to obtain the given characteristic of this device.
- Briefly explain how this diode can be used as a voltage regulator Zener diode



Across the zener diode voltage remains constant even though the current through it changes. Example if the input voltage decreases, the current through the series resistor in the circuit decreases and through the zener diode also decreases.

The voltage across the series resistor will decrease but the voltage across the zener diode will not change. Thus the zener diode acts as a voltage regulator.

Question: 27

An inductor 200 mH, capacitor 500mF, resistor 10W are connected in series with a 100V, variable frequency AC source. Calculate the

- frequency at which the power factor of the circuit is unity
- current amplitude at this frequency

[5]

Answer:

Power factor is unity at resonance as, $f = 0$

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



Substitute values and calculate

At resonance, $Z = R$

$$i = \frac{V}{R} = \frac{100}{10}$$

$$Q = \frac{\omega L}{R}$$

Question: 28 ()**

[5]

- For a ray of light traveling from a denser medium of refractive index n_1 to a rarer medium of refractive index n_2 , prove that $\sin i_c = \frac{n_2}{n_1}$, where i_c is the critical angle of incidence for the media.
- Explain with the help of a diagram, how the above principle is used for transmission of video signals using optical fibers.

OR

- What is plane polarized light? Two polaroids are placed at 90° to each other and the transmitted intensity is zero. What happens when one more Polaroid is placed between these two, bisecting the angle between them? How will the intensity of transmitted light vary on further rotating the third Polaroid?
- If a light beam shows no intensity variation when transmitted through a Polaroid which is rotated, does it mean that the light is unpolarized? Explain briefly.

$$\frac{n_2}{n_1} = \frac{\sin i}{\sin r} = \frac{\sin i_c}{\sin 90^\circ} = \sin i_c$$

Question: 29 ()**

[5]

- Using Gauss' law, derive an expression for the electric field intensity at any point outside a uniformly charged thin spherical shell of radius R and charge density σ C/m². Draw the field lines when the charge density of the sphere
 - Positive.
 - Negative.
- A uniformly charged conducting sphere of 2.5 m in diameter has a surface charge density of 100 mC/m². Calculate the
 - Charge on the sphere.
 - Total electric flux passing through the sphere.

OR

- Derive an expression for the torque experienced by an electric dipole kept in a uniform electric field.
- Calculate the work done to dissociate the system of three charges placed on the vertices of a triangle as shown: Here $q = 1.6 \times 10^{-10}$ C.

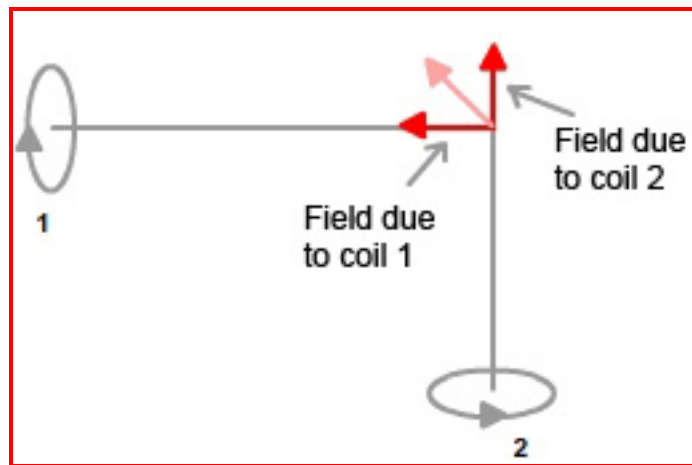
Question: 30

Using Biot-Savart's law, derive an expression for the magnetic field at the centre of a circular coil of radius R , number of turns N , carrying current i . See derivation in NCERT book for field along the axis. Then take special case for center of coil.

[5]



Answer:



Field due to coil 1 is:

$$B_1 = B_2$$
$$= \frac{\mu_0 I R^2}{2(x^2 + R^2)^{3/2}}$$

Resultant:

$$\sqrt{2}B_1 = \sqrt{2} \cdot \frac{\mu_0 I R^2}{2(x^2 + R^2)^{3/2}}$$

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

