2011

Set: I

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Question: 1

Define electric dipole moment. Write its S.I. unit. [1]

Answer:
Dipole moment is a measure of strength of electric dipole. It is a vector quantity whose magnitude is equal to product of the magnitude of either charge or the distance between them.
SI unit of dipole moment is coulomb-metre (c-m).

Question: 2

Where on the surface of Earth is the angle of dip 90^0? [1]

Answer:
Magnetic dip is the angle made by a compass needle with the horizontal point at any point on the earth's surface.

Question: 3

A hollow metal sphere of radius 5 cm is charged such that the potential on its surface is 10 V. What is the potential at the center of the sphere? [1]

Answer:
Potential inside the charged sphere is constant and equal to potential on the surface of the conductor so, therefore, potential at the center of the sphere is 10V.

Question: 4

How are radio waves produced? [1]

Answer:
These are the electromagnetic waves of frequency ranging from 500 KHz to about 1000 MHz. these waves are used in the field of radio communication.

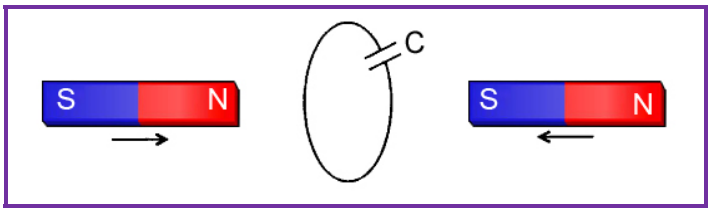
Question: 5

Write any two characteristic properties of nuclear force. [1]

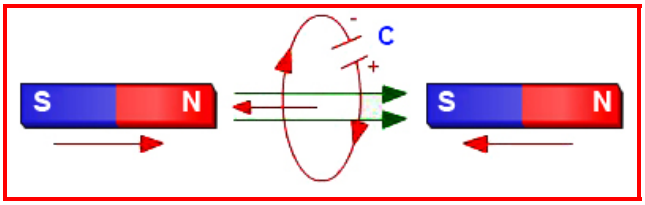
Answer:
Characteristic properties of nuclear force are:
i. It does not depend on the electric charge.
ii. It is the strongest force in nature.

Question: 6

Two bar magnets are quickly moved towards a metallic loop connected across a capacitor 'C' as shown in the figure. Predict the polarity of the capacitor. [1]



Answer:



Red lines represent the magnetic lines due to the magnets. Blue line represents the magnetic line due to the current induced in the loop. Polarity of the capacitor: lower plate is positive, upper plate is negative.

Question: 7

What happens to the width of depletion layer of a p-n junction when it is
i. forward biased
ii. Reverse biased? [1]

Answer:
See topics on 'I-V characteristics in Forward and Reverse Bias'.

Question: 8

Define the term 'stopping potential' in relation to photoelectric effect. [1]

Answer:
See topics on 'photoelectric effect'.

Question: 9

A thin straight infinitely long conducting wire having charge density λ is enclosed by a cylindrical surface of radius r and length l, its axis coinciding with the length of the wire. Find the expression for the electric flux through the surface of the cylinder. [2]

Answer:
See topics on 'electric flux'.

Question: 10

Plot a graph showing the variation of Coulomb force (F) versus (1/r2), where r is the distance between the two charges of each pair of charges: (1μC, 2μC) and (2μC - 3μC). Interpret the graphs obtained. [2]

Answer:
See topics on Coulomb's law'.

Question: 11

Write the expression for Lorentz magnetic force on the particle of charge 'q' moving with velocity $\vec{v}$ in a magnetic field $\vec{B}$. Show that no work is done by this force on the charged particle. [2]

Answer:
See topics on 'A uniform magnetic field'.

OR

A steady current (I_1) flows through a long straight wire. Another wire carrying steady current (I_2) in the same direction is kept close and parallel to the first wire. Show with the help of a diagram how the magnetic field due to the current I_1 exerts a magnetic force on the second wire. Write the expression for this force.

Answer:
See topics on 'mutual'

Question: 12

What are eddy currents? Write any two applications of eddy currents. [2]

Answer:
See topics on 'Eddy currents'.

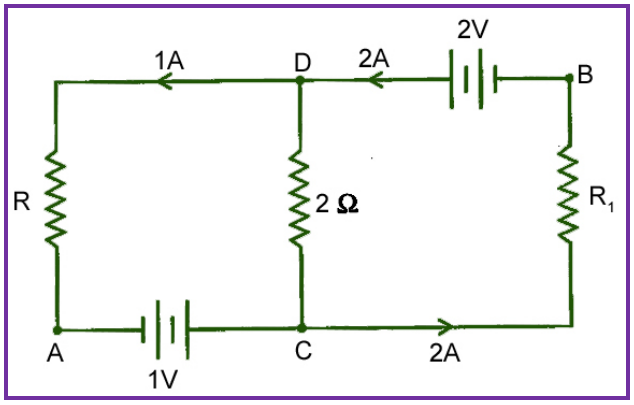
Question: 13

What is sky wave communication? Why this mode of propagation is restricted to the frequencies only up to few MHz? [2]

Answer:
See topics on 'Sky'.

Question: 14

In the given circuit, assuming point A to be zero potential, use Kirchhoff's rules to determine the potential at point B. [2]



Answer:
See topics on 'Kirchhoff's laws'.

Question: 15

A parallel plate capacitor is being charged by a time varying current. Explain briefly how Ampere's circuital law is generalized to incorporate the effect due to the displacement current. [2]

Answer:
See topics on 'Ampere's law'.

Question: 16 (**)

Let capacitance of three identical capacitors is series is 1 F. What will be their net capacitance if connected in parallel? Find the ratio of energy stored in the two configurations if they are both connected to the same source. [2]

Question: 17

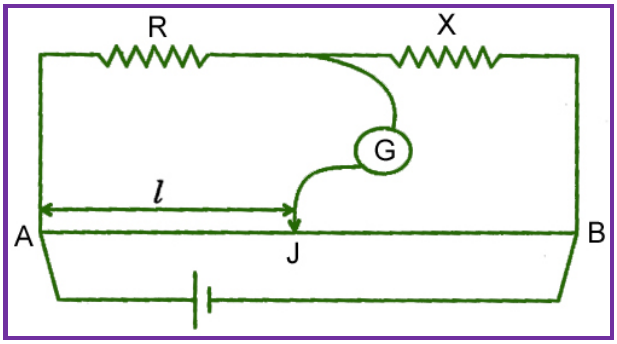
Using the curve for the binding energy per nucleon as a function of mass number A, state clearly the release in energy in the processes of nuclear fission and nuclear fusion can be explained. [2]

Answer:
See topics on 'mass defect'.

Question: 18 [2]

In the meter bridge experiment, balance point was observed at J with AJ = l.

a. The values of R and X were doubled and then interchanged. What would be the new position of balance point?



Answer:

As the ratio of $\frac{R}{X}$ is now interchanged by

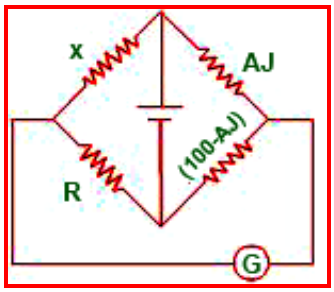
$\frac{2X}{2R}=\frac{X}{R}$

= -100 - l

= 100 – AJ $\left(\text{as, } \frac{R}{X}=\frac{1}{100-1}\right)$

b. If the galvanometer and battery are interchanged at the balance position, how will the balance point get affected?

Answer:



At the balance position there is no current flowing through the galvanometer. Hence, interchanging the battery and the galvanometer will have no effect on the balance point.

Question: 19 *(**)*

A convex lens made up of glass of refractive index 1.5 is dipped, in turn, in (i) a medium of refractive index 1.65 (ii) a medium of refractive index 1.33.

a. Will it behave as a converging or a diverging lens in the two cases?

b. How will its focal length change in the two media?

Question: 20

Draw a plot showing the variation of photoelectric current with collector plate potential for two different frequencies, $v_1 > v_2$, of incident radiation having the same intensity. In which case will the stopping potential be higher? Justify your answer. [3]

Answer:

See topics on photoelectric effect'

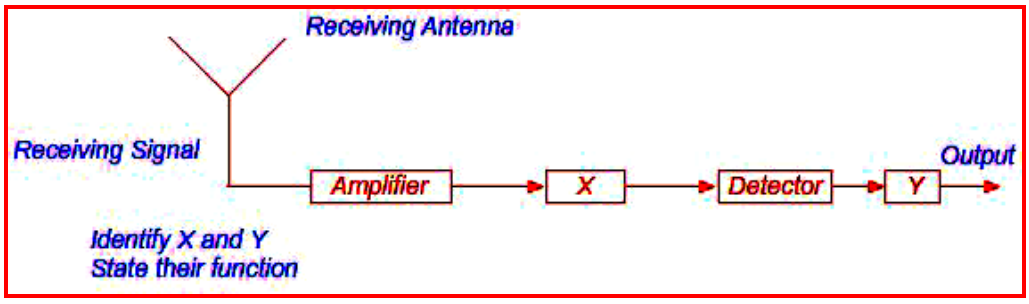
Question: 21

Write briefly any two factors which demonstrate the need for modulating a signal. Draw a suitable diagram to show amplitude modulation using a sinusoidal signal as the modulating signal. [3]

Answer:

Factors which demonstrate the need for modulating a signal are:

- Size of antenna would be very large in the absence of modulation.
- Effective power radiated by the antenna would be small in the absence of modulation.



Question: 22

Use the mirror equation to show that

a. An object placed between f and 2f of a concave mirror produces a real image beyond 2f. [3]

Answer:

For concave mirror, the focal length (f) is negative. $f < 0$

When the object is placed on the left of the mirror, the object distance (u) is negative. $u < 0$. For image distance v, we can write the lens formula as:

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \quad \text{(i)}$$

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

$\therefore 2f < u < f$ ($\because$ u and f are negative)

or, $\frac{1}{2f} > \frac{1}{u} > \frac{1}{f}$

$= -\frac{1}{2f} < \frac{1}{u} < \frac{1}{f}$

So, $\frac{1}{f} - \frac{1}{2f} < \frac{1}{f} - \frac{1}{u} < 0$ (ii)

Using equation (i), we get

$\frac{1}{2f} < \frac{1}{v} < 0$

$\frac{1}{v}$ is negative, i.e. v is negative

$\frac{1}{2f} < \frac{1}{v}$

$2f > v$

$-v > -2f$

Therefore, the image lies beyond 2f.

b. A convex mirror always produces a virtual image independent of the location of the object.

Answer:

$f > 0$. For image distance v, we have the mirror formula:

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

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

Using equation (ii), we can conclude that:

$$\frac{1}{v} < 0$$

Thus, the image is formed on the back side of the mirror.

Hence, a convex mirror always produces a virtual image, regardless of the object distance.

c. An object placed between the pole and focus of a concave mirror produces a virtual and enlarged image.

Answer:

For a concave mirror, the focal length (f) is negative.

f < 0 when the object is placed on the left side of the mirror, the object distance (u) is negative. u < 0

It is placed between the focus (f) and the pole.

$\therefore f > u > 0$

$$\frac{1}{f} < \frac{1}{u} < 0$$

$$\frac{1}{f} - \frac{1}{u} < 0$$

For image distance v, we have the mirror formula:

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

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

$$\therefore \frac{1}{v} < 0$$

v > 0

The image is formed on the right side of the mirror. Hence,

Question: 23

Draw a labeled diagram of a full wave rectifier circuit. State its working principle. Show the input-output waveforms. [3]

Answer:

See topics on 'full wave'.

Question: 24

a. Using deBroglie's hypothesis, explain with the help of a suitable diagram, Bohr's second postulate of quantization of energy levels in a hydrogen atom. [3]

Answer:

See topics on 'Applying de Broglie hypotheses'.

b. The ground state energy of hydrogen atom is – 13.6 eV. What are the kinetic and potential energies of the electron in this state?

Answer:

Ground state energy of hydrogen atom: E = − 13.6 eV

This is the total energy of a hydrogen atom. Kinetic energy is equal to the negative of the total energy.

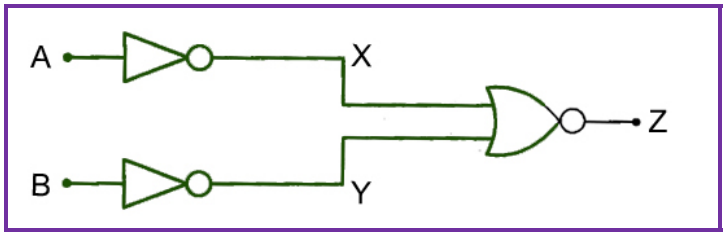
Kinetic energy (− E):

= − (− 13.6)
= 13.6 eV

Potential energy is equal to the negative of two times of kinetic energy. Then potential energy:
= − 2 × (13.6)
= − 27 .2 eV

Question: 25

You are given a circuit below. Write its truth table. Hence, identify the logic operation carried out by this circuit. Draw the logic symbol of the gate it corresponds to. [3]



Answer:
See topics on 'NOR gate'.

Question: 26

A compound microscope uses an objective lens of focal length 4cm and eyepiece lens of focal length 10 cm. An object is placed at 6cm from the objective lens. Calculate the magnifying power of the compound microscope. Also calculate the length of the microscope. [3]

Answer:
See topics on 'compound'.

OR

a. A giant refracting telescope at an observatory has an objective lens of focal length 15 m. if an eyepiece lens of focal length 1.0 cm is used. Find the angular magnification of the telescope.

Answer:
Focal length of the objective lens (f_o): 15m = 15 x 102 cm
Focal length of the eyepiece (f_e): 1.0 cm, then,

$$\alpha = \frac{f_o}{f_e}$$

$$= \frac{15 \times 10^2}{1.0}$$

=1500.
Hence, the angular magnification of the given refracting telescope is 1500.

b. If this telescope is used to view the moon, what is the diameter of the image of the moon formed by the objective lens? The diameter of the moon is 3.42×10^6 m and the radius of the lunar orbit is 3.8×10^8 m.

Answer:
Diameter of the moon (d): 3.42×10^6 m
Radius of the lunar orbit (r_0): 3.8×10^8 m

Let, d' be the diameter of the image of the moon formed by the objective lens. The angle subtended by the diameter of the moon is equal to the angle subtended by the image.

Since, $\frac{d}{r_0} = \frac{d'}{f_0}$

Then, $\frac{3.42 \times 10^6}{3.8 \times 10^8} = \frac{d'}{15}$

or, $d' = \frac{3.42}{3.8} \times 10^{-2} \times 15$

= .91 x 10-2 m
= .91 cm.

Question: 27

Two heating elements of resistances R_1 and R_2 when operated at a constant supply of voltage, V, consume powers P_1 and P_2 respectively. Deduce the expressions for the power of their combination when they are, in turn, connected in (i) series and (ii) parallel across the same voltage supply. [3]

Answer:
See topics on 'In series'.

Question: 28

i. State the principle of the working of a moving coil galvanometer, giving its labeled diagram.

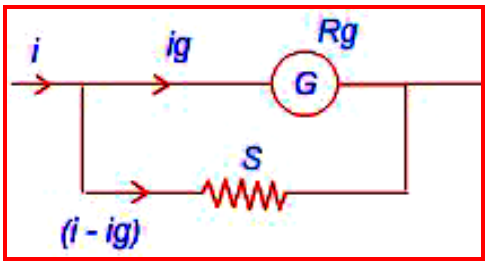
Answer:
See topics on 'Moving coil galvanometer'.

ii. "Increasing the current sensitivity of a galvanometer may not necessarily increase its voltage sensitivity." Justify this statement.

Answer:
Unlike current sensitivity, the voltage depends upon number of turns as well on to the resistance of the coil.

iii. Outline the necessary steps to convert a galvanometer of resistance R_G into an ammeter of a given range.

Answer:



To convert galvanometer into ammeter of range 0 to i, we have to connect a low resistance shunt in parallel. $S = \frac{i_g}{(i - i_g)} R_g$

OR

i. Using Ampere's circuital law, obtain the expression for the magnetic field due to a long solenoid at a point inside the solenoid on its axis.

Answer:
See topics on 'Ampere's law'.

ii. In what respect is a toroid different from a solenoid? Draw and compare the pattern of the magnetic field lines in the two cases.

Answer:
See topics on 'Solenoids'.

iii. How is the magnetic field inside a given solenoid made strong?

Answer:
The magnetic field inside the given solenoid is made strong by following ones:
a. By inserting a ferromagnetic substance inside the solenoid
b. By increasing the amount of current through the solenoid

Question: 29 [5]

State the working of AC generator with the help of a labeled diagram.

Answer:
See topics on 'Generator'.

i. The coil of an AC generator having N turns, each of area A, is rotated with a constant angular velocity ω. Deduce the expression for the alternating e.m.f generated in the coil.

Answer:
As the coil rotates angle θ changes. Therefore, magnetic flux φ linked with the coil changes and hence, an emf induced in the coil. At this instant t, if e is the emf induced in the coil, then

$$e = -\frac{d\theta}{dt}$$

$$= -\frac{d}{dt}(NAB \cos \omega t)$$

$= -NAB.\frac{d}{dt}(\cos \omega t)$

$= -NAB.(-\sin \omega t)\omega$

ii. What is the source of energy generation in this device?

Answer:

The generator converts the mechanical energy into electrical energy. The mechanical energy may be obtained from the turbine associated with the generator. The turbine in turn, may be working by the kinetic energy of running water, wind or steam.

OR

i. Show that in an AC circuit containing a pure inductor, the voltage is ahead of current by $\frac{\pi}{2}$ in phase.

Answer:

AC voltage applied to an inductor

Source v = vm sin ωt

Using Kirchhoff's loop rule,

$\sum \varepsilon(t) = 0$

$v = \frac{Ldi}{dt} = 0$

$\frac{di}{dt} \cdot \frac{v}{L} = \frac{vm}{L} \cdot \sin \omega t$

Integrating di/dt with respect to time,

$\int \frac{di}{dt} dt = \frac{vm}{L} \cdot \int \sin(\omega t) dt$

$i = \frac{vm}{\omega L} \cos(\omega t) + constant$

$-\cos \omega t = \sin\left(\omega t - \frac{\pi}{2}\right)$

$\therefore i = im.\sin\left(\omega t - \frac{\pi}{2}\right)$

$\because$ where $im = \frac{vm}{\omega L}$ is the amplitude of current

ii. A horizontal straight wire of length L extending from east to west is falling with speed v at right angles to the horizontal component of earth's magnetic field B.

a. Write the expression for the instantaneous value of the e.m.f. induced in the wire.

Answer:

As the wire fall downwards due to this motion e^- within the wire moves downwards and feels a force due to earth's magnetic field towards west

$\vec{F} = -e\vec{v} \times \vec{B} \Rightarrow F - evB$

As electrons moves towards west end of wire they apply opposite or repelling force to new incoming charge. As more and more electron's come, eventually we achieve an equilibrium situation where no more electrons can come towards west side end.

At this particular situation

eE = -evB
E = -vB
V = -EL
$\Rightarrow$ V = vBL e.m.f setup within the wire

b. What is the direction of the e.m.f?

Answer:
The direction of the e.m.f will be the polarity of the rod, which is positive at the east end and negative at the west end.

c. Which end of the wire is at the higher potential?

Answer:
As the electrons get accumulated at the west end it would mean that the west end is at negative potential which implies east end is at high potential (nonzero potential)

Question: 30 [5]

State the importance of coherent sources in the phenomenon of interference.

a. In Young's double slit experiment to produce interference pattern, obtain the conditions for constructive and destructive interference. Hence deduce the expression for the fringe width.

Answer:
See topics on 'Generator'.

b. How does the fringe width get affected, if the entire experimental apparatus of Young is immersed in water?

Answer:
See topics on 'Double slit experiment'.

OR

a. State Huygens's principle. Using this principle explain how a diffraction pattern is obtained on a screen due to a narrow slit on which a narrow beam coming from a monochromatic source of light is incident normally.

Answer:
See topics on 'Huygens's principle'.

b. Show that the angular width of the first diffraction fringe is half of that of the central fringe.

Answer:
Derivation to show,

- β or $\theta = \frac{\lambda}{d}$ for interference central fringe, and

- β or $\theta = \frac{\lambda}{2d}$ for diffraction first fringe

c. If a monochromatic source of light is replaced by white light, what change would you observe in the diffraction pattern?

Answer:

Following changes will be observed:

- Central fringe will be bright but subsequent bright fringes will be colored instead of just being bright.
- Fringe width, angular fringe width will not be constant.

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