2011

Part: I

Question: 1 [5]

Answer all questions

1. Choose the correct alternatives A,B, C or D for each of the questions given below:

a. Two point charges (+e) and (-e) are kept inside a metallic cube without touching its sides. Electric flux emerging out of the cube is:

- O $\frac{e}{\epsilon_0}$
- O $\frac{-e}{\epsilon_0}$
- O Zero
- O $\frac{2e}{\epsilon_0}$

Answer:

b. In current electricity, Ohm's law is obeyed by all:

- O Solids
- O Metals
- O Liquids
- O Gases

Answer:

c. When a charged particle is projected perpendicular to a uniform magnetic field, it describes a circular path in which:

- O Its speed remains constant
- O Its velocity remains constant
- O Its momentum remains constant
- O Its kinetic energy increases

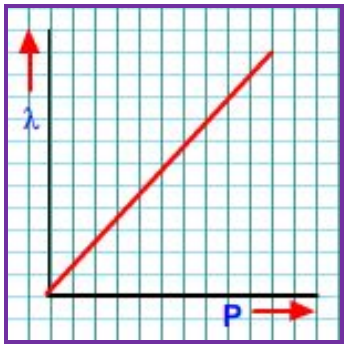
Answer:

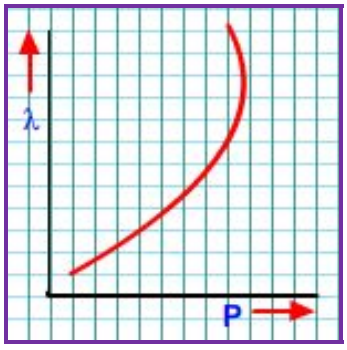
d. Refractive index of a transparent material

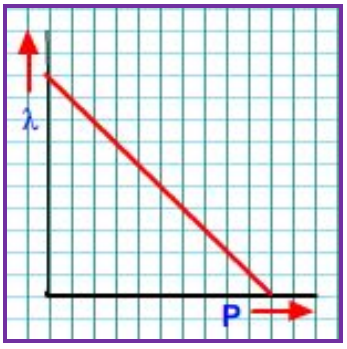
- Same for all colors
- Maximum for violet color
- Maximum for violet color
- Maximum for red color

Answer:

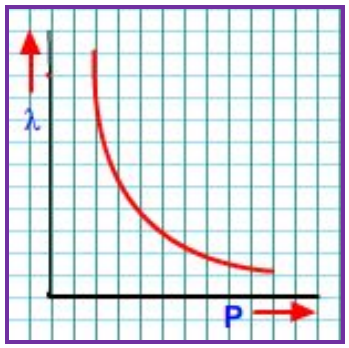
e. Which one of the following graphs represents variation of de Broglie wavelengths (λ) of a particle having linear momentum p:

- 

- 

- 

O



Answer:

2. Answer all questions briefly and to the point: [15]

a. How much work is done in taking an electron around a nucleus in a circular path?

Answer:
w = 0.

b. A 10 m long potentiometer wire carries a steady current. A standard cell of emf 1.018 V is balanced against a length of 254.5 cm of the wire. What is the potential gradient across the potentiometer wire?

Answer:
Emf = 1.018 V,
Length = 254.5 cm

$K = \frac{E}{l} = \frac{1.018}{254.5} = 0.004 \text{ V / cm}.$

c. Name any one instrument which works on the principle of Tangent law in magnetism.

Answer:
Tangent galvanometer.

d. An inductor L and a resistance R are connected in series to a battery, through a key / switch. Show graphically, how current decreases with time when the key/switch is opened.

Answer:
Graph showing the decrease of current with time.

e. An ideal inductor does not consume any power even though both V and I are non-zero. Explain in brief.

Answer:
For an ideal inductor the phase angle is 90^0.

We know,
$P_{av} = E_{rms} \times i_{rms} \times \cos \varphi$
$= E_{rms} \times i_{rms} \times \cos 90^0$
$= 0$

f. In Fraunhofer's single slit diffraction experiment, how does semi-angular with θ of the central bright fringe depend on slit with 'a'?

Answer:

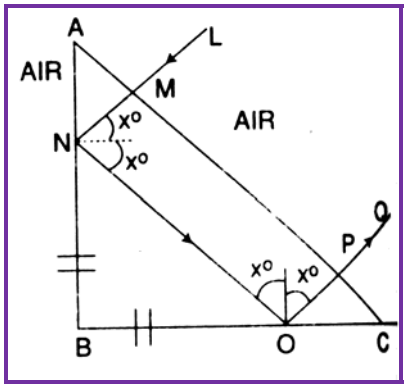
We know $\theta = \lambda/a$ where λ is wavelength of light and 'a' is the slit width. So, as slit width increases the semi angular width of the central bright fringe decreases.

g. State one use of a Polaroid.

Answer:

Polaroid's are used in wind screen of the cars.

h.



In above diagram we see a ray of light LM incident normally on the surface AC of an isosceles right angled prism ABC (where AB = BC) emerges along PQ, parallel to LM. What can you say about refractive index μ of the material of the prism?

Answer:

$\angle A = \angle C = 45^0$ $\angle i = 45^0$

For total internal reflection to take place at faces;

$\text{Sin}i > \frac{1}{n}$ $\text{Sin}45 > \frac{1}{n}$ $n > \frac{1}{\text{Sin}45}$ $n > \sqrt{2}$.

R.I of prism is greater than $\sqrt{2}$

i. State one condition for obtaining a sustained interference of light.

Answer:

For sustained interference of light the two interfering sources must be coherent.

j. State any one postulate of Huygens's wave theory.

Answer:

Every particle of the medium situated on the wave front acts as a new wave source from which the fresh wave originates. These waves are called secondary wavelets.

k. How can an n type of semiconductor be obtained from a pure crystal germanium?

Answer:
'n' type semiconductor can be obtained from a pure crystal of germanium by adding pentavalent impurity atom such as antimony, phosphorous or arsenic.

l. In the following nuclear reaction: ${}^{11}_{6}C \rightarrow {}^{11}_{5}B + {}^{0}_{1}e + X$. What does X stand for?

Answer:
Here, in, ${}_{6}C^{11} \rightarrow {}_{5}B^{11} + {}_{1}e^{0} + X$, X stands for energy.

m. In photoelectric effect, what is meant by the term 'threshold frequency'?

Answer:
See topics on 'Threshold frequency'.

n. Find angular momentum of an electron when it is the second Bohr orbit of hydrogen atom.

Answer:
Angular momentum = mvr

$$= \frac{nh}{2\pi} = \frac{2h}{2\pi} = \frac{h}{\pi}$$

$$= \frac{6.6 \times 10^{-34}}{3.14}$$

$$= 2.10 \times 10^{-34} \text{ Kgm}^2 / \text{s}$$

o. What is the symbol of a NOT gate?

Answer:
See topics on 'NOT'.

Part: II

Answer six questions in this part, choosing two questions from each of the Sections A, B and C

Section: A

Answer any two questions

Question: 2

i. Obtain an expression for intensity of electric field in end on position, i.e. axial position of an electric dipole. [4]

Answer:
See topics on 'Axial point'.

ii. Three capacitors each of capacitance C are connected in series. Their equivalent capacitance is Cs. The same three capacitors are now connected in parallel. Their equivalent capacitance becomes Cp, find the ratio $\left(\frac{C_p}{C_s}\right)$. (Working must be shown). [3]

Answer:

3 Capacitors each of capacitance c.

Series capacitance: C_s
Parallel capacitance: C_p

$C_p = C + C + C = 3C$

$$\frac{1}{C_s} = \frac{1}{C} + \frac{1}{C} + \frac{1}{C}$$

$$\frac{1}{C_s} = \frac{3}{C}$$

$$C_s = \frac{C}{3}$$

$$\frac{C_p}{C_s} = \frac{3C}{C/3} = 9$$

iii. A galvanometer with a resistance of 75Ω produces a full scale deflection with a current of 5 mA. How can this galvanometer be converted into an ammeter which has a range of 0-5A? [2]

Answer:

γ = 75Ω, ig = 5mA, Range = 0 to 5A

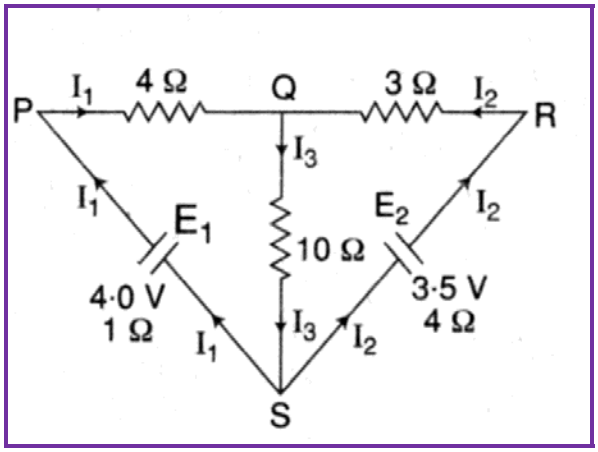
We know, $5\ \frac{i_g G}{i - i_g}$

$$= \frac{5 \times 10^{-3} \times 75}{5 - 5 \times 10^{-3}}$$

$= 0.075\Omega$

Question: 3

i. In the circuit diagram shown below, E_1 and E_2 are batteries having emfs 4.0V and 3.5V respectively and internal resistance 1Ω and 2Ω respectively. Using Kirchhoff's law, calculate currents: I_1, I_2 and I_3. [4]



Answer:

$T_0 = 10^0 C$, $T_n = 270^0 C$, $T_i = ?$

$T_n = \frac{T_0 + T_i}{2}$

or, $T_i = 2T_n - T_0$

$= 2 \times 270^0 - 20^0$

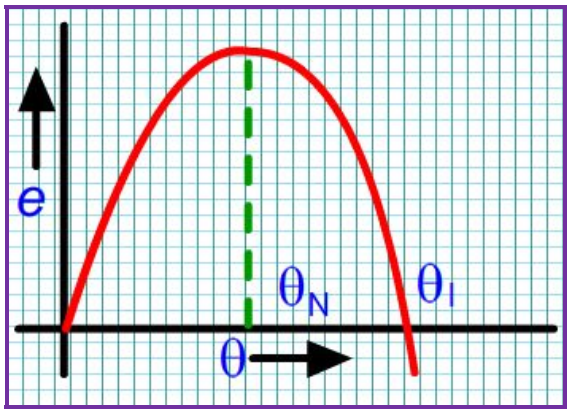
$= 540^0 - 20^0$

$= 520^0 C$

ii. Show, with the help of a labeled graph, how thermo emf 'e' developed by a thermocouple varies with θ, the temperature difference between the two junctions. On the graph, mark neutral temperature as θ_N and temperature of inversion as θ_1. [2]

Answer:

Graph below shows the variation of thermo e.m.f 'e' with temp diff. between the two where θ_N shows neutral temperature and θ_1 shows inversion temperature



iii.

a. What is meant by paramagnetic substance? State Curie's law.

Answer:

See topics on 'Paramagnet'.

b. What is the value of magnetic susceptibility of Aluminum if its relative permeability is 1.000022? [3]

Answer:

Given, μr = 1.000022.

We know,

μr = 1 + χ_m 1.000022

= 1 + χ_m

So, χ_m = 0.000022

Question: 4

i. Using Ampere's circuital law or Biot and Savart's law, show that magnetic flux density 'B' at a point 'P' at a perpendicular distance 'a' from a long current carrying conductor is given by:

$B = \left(\frac{\mu_0}{4\pi}\right)\frac{21}{a}$ (Statement of the laws – not required) [3]

Answer:

See topics on 'Flux density at a distance r'.

ii. A current of 4A flows in a coil when it is connected to a 12V dc source. When the same coil is connected to an AC source (12V, 8Hz), a current of 2.4 A flows in the coil. Calculate coefficient of self-inductance (L) of the coil. [4]

Answer:

Given, 4A, 12V de Source. 2.4A when connected to 12V, 8Hz ac source.

We know,
V = IR
12 = 4 x R r = 3 ohm.
i = E / ℑ 2.4 = 12/ ℑ
ℑ = 5 ohm but,

$I = \sqrt{R^2 + X_L^{\ 2}}$

$5 = \sqrt{3^2 + X_L^{\ 2}}$

X_L = 4 ohm, but,
X_L = 2πtL 4
= 2π x 8 x L

L = 0.0796 Henry

iii. How much force per unit length acts on a long current carrying conductor X due to a current flowing through another similar conductor Y, kept parallel to it a vacuum? Use this equation to define an Ampere, the fundamental unit of current. [2]

Answer:

Force per unit length is given by, $\frac{F}{l} = \frac{\mu_0}{2\pi}\frac{i_1 - i_2}{R}$.

Where,
i_1 is the current in X
I^2 is the current in Y
R is the distance between them

Definition of Ampere:

1 ampere is the current which when flowing in each of the two indefinitely long parallel conductors 1m apart in vacuum produces between them a force of exactly 2 x 10^{-7} N/m of length.

Section: B

Question: 5

i.

a. Arrange all the seven types of electro-magnetic radiations in increasing order of their frequencies. (You must begin with a radiation with lowest frequency and end with the one having the highest frequency). [3]

Answer:

Radio waves, microwaves, infrared, visible, u-v, X-rays and Gamma rays.

b. State how electric vector $\vec{E}$, magnetic vector $\vec{B}$ and velocity vector $\vec{C}$ are oriented in an electromagnetic wave. [2]

Answer:

In electromagnetic wave propagating along X-direction electric vector $\vec{E}$, magnetic vector $\vec{B}$ are taken in the Y-7 plane and $\vec{C}$ taken along X-direction.

ii. In Young's double experiment, using monochromatic light L_1 of wavelength 700 nm, 10^{th} bright fringe was obtained at a certain point P on a screen. Which bright fringe will be obtained at the same point P if monochromatic light of wavelength 500 nm is used in place of L_1 (No other alterations were made in the experiment set up). [3]

Answer:

Given $\lambda_1 = 700nm, 10th\ bright\ fringe.$

$\lambda_2 = 500nm,\ n^2 = ?$

We know, $n_1\lambda_1 = n_2\lambda_2$

$$n_2 = \frac{n_1\lambda_1}{\lambda_2}$$

$$= \frac{10 \times 700}{500} = 14$$

iii. A certain monochromatic light travelling in air is incident on a glass plate at a polarizing angle. Angle of refraction in glass is found to be 320. Calculate, [2]

a. The polarizing angle?

Answer:

Given, $\angle r = 32^o$

$i_p + r = 90^o$

$i_p + 32 = 90^o$

$\angle i_p = 58$

b. Refractive index of glass?

Answer:

$n = \tan i_p$

$n = \tan 58$

$= 1.6$

Question: 6

i. Calculate angle of minimum deviation (δ_m) for a regular glass prism. (Refractive index of glass is 1.6) [3]

Answer:

Given, n = 1.6 sin =?

We know, $n = \frac{\sin\left(\frac{A + \sin}{2}\right)}{\sin A/2}$

$1.6 = \frac{\sin\left(\frac{60 + \sin}{2}\right)}{\sin\left(\frac{60}{2}\right)} \times 53.13$

$= \frac{60 + \sin}{2}$

$\therefore \sin = 46.26^0$

ii. Obtain an expression for refraction at a single convex spherical surface. i.e. the relation between μ_1 (rarer medium), μ_2(denser medium), the object distance u, image distance v and radius of curvature R. [2]

Answer:

See topics on 'Spherical surface'.

iii. Where an object should be kept on the principal axis of a convex lens of focal length 20 cm, in order to get an image, which is double the size of the object? [4]

Answer:

Given, f = 20 cm, m = 2 then, u = ?

We know, $m = \frac{v}{u}.2 = \frac{v}{u}.v = 2u$

We also know,

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

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

$= \frac{1}{f}$, then

$u = 30cm$

Question: 7

i. [3]

a. What is the use of a spectrometer?

Answer:

Spectrometer is used to observe the pure spectrum.

b. In a spectrometer, what is the function of

i. Collimator?

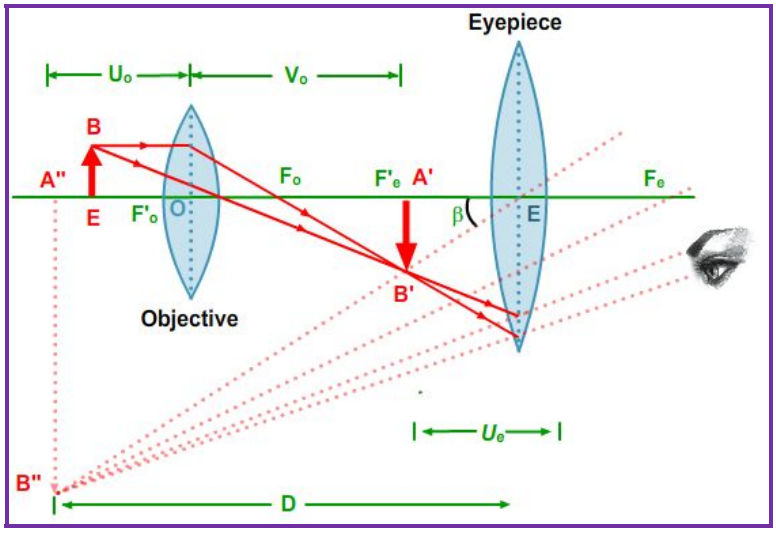
Answer:
Its function is to render the rays parallel.

ii. Telescope?

Answer:
It is used to observe the spectrum.

iii. Draw a labeled diagram of an image formed by a compound microscope with image at least distance of distinct vision. [3]

Answer:



iv. An astronomical telescope consists of two thin convex lenses having focal lengths of 140cm and 5cm. The telescope is adjusted to be in normal adjustment.

a. What is the angular magnification, i.e. magnifying power of the telescope in this set up?

Answer:
Angular magnification,

$$m = \frac{-f_0}{f_e}$$

$$= \frac{-140}{5}$$

$$= -28$$

b. What is the distance between the two lenses equal to?

Answer:
$L = f_0 + f_e$

= 140 + 5
= 145 cm.

Section: C

Question: 8

i. State two important conclusions that can be drawn from Millikan's oil drop experiment to determine the charge of an electron. [3]

Answer:
It establishes quantum nature of charge. He found the charge of an e – equal to 1.6×10^{-19}C.

ii. A monochromatic source of light emits light of wavelength 198 nm. Calculate: [2]

a. Energy of each photon:

Answer:

$$E = \frac{hc}{\lambda}$$

$$= \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{198 \times 10^{-9}}$$

$$= 1 \times 10^{18} \text{ J}$$

b. Momentum of the photon

Answer:

$$\lambda = \frac{h}{p} \quad p = \frac{6.6 \times 10^{-34}}{198 \times 10^{-9}}$$

$$= 3.33 \times 10^{-22} \text{ kg m/s}$$

iii. [3]

a. Name a series of lines of hydrogen spectrum which lies on: Visible region and Ultra violet region

Answer:
Visible region → Balmer series
Ultra violet region → Lyman series.

b. Write Bohr's formula to calculate wavelength (λ) of visible light, emitted by hydrogen and explain the meaning of each and every symbol used.

Answer:
Bohr's formula,

$$\frac{1}{\lambda} = \tau^2 R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

for hydrogen, $\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

Question: 9

i. Starting with the law of radioactive disintegration, show that: $N = N_{0e}^{-\lambda t}$, where the terms have their usual meaning. [3]

Answer:

Let N be the number of atoms present in a radioactive substance at any instant. Then,

$$-\frac{dN}{dt} = \lambda N$$

Where λ is decay constant then, $\frac{dN}{dt} = \lambda dt$, where, C is the integration constant. Suppose there were no atoms in the beginning them, $N = N_0$ at t = 0.

So, loge N_0 = C

Putting this in the above equation,

$$\log_e N = -\lambda^{+} + \log_e N_0$$

$$\log_e N - \log_e N_0 = -\lambda^{+}$$

$$\log_e \frac{N}{N_O} = -\lambda^{+}$$

$$\frac{N}{N_O} = e - \lambda +$$

ii. What is meant by Pair Production? Explain with the help of an example and a balanced equation. [2]

Answer:

See topics on 'Pair production'.

iii. An X ray tube is operated at a tube potential of 40,000 V. Calculate: [3]

a. Kinetic energy of an electron emitted by the filament when it reaches the target / anode.

Answer:

Given, V = 40,000 V.

We know,

KE = eV.
= $1.6 \times 10^{-19} \times 40{,}000$
= 6.4×10^{-15} J.

b. Wavelengths of all the X rays emitted by the X ray tube.

Answer:

We know, $\lambda min = \frac{hc}{eV}$

$$= \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{1.6 \times 10^{-19} \times 40{,}000}$$

$$= \frac{1.98 \times 10^{-25}}{1.6 \times 10^{-19} \times 40{,}000}$$

$$= 3.09375 \overset{0}{A}$$

Question: 10

i.

a. In the following nuclear reaction, calculate the energy released in MeV: ${}_{1}^{2}H + {}_{1}^{2}H \rightarrow {}_{2}^{3}He + {}_{0}^{1}n$

Given that: Mass of ${}_{1}^{2}H$ =2.015 u

Mass of ${}_{2}^{3}He$ =3.017 u

Mass of ${}_{0}^{1}n$ = 1.009 u [3]

Answer:

Mass of reactants: 2.015 x 2 = 4.030 u
Mass of products: 3.017 + 1.009 = 4.026 u
Mass defect sin: 0.004u
We know 1u: 931 MeV.

So, Energy Released
= 0.004 x 931 = 3.724 MeV

b. What is the name of this reaction? [3]

Answer:

Fusion reaction.

ii. What is meant by the terms: [3]

a. A full wave rectifier

Answer:

Full wave rectifier: It converts alternating current into direct current. In this complete conversion of AC to DC takes place'.

b. An amplifier

Answer:

An amplifier: A device which amplify a signal. A junction diode cannot amplify a signal. A transistor consisting of two p-n junctions one toward biased and the other reverse bias is used to amplify a weak signal.'

c. An oscillator

Answer:

Oscillator

It is a device that generates electrical oscillations of constant amplitude and of desired frequency, without any external input. .

iii. Using several NAND gates, how can you obtain an AND gate? Draw a labeled diagram in support of your answer.

Answer:

Truth table:

A	B	Y'	Y
0	0	1	0
0	1	1	0
1	0	1	0
1	1	0	1