
2015

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Part II

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Part: I

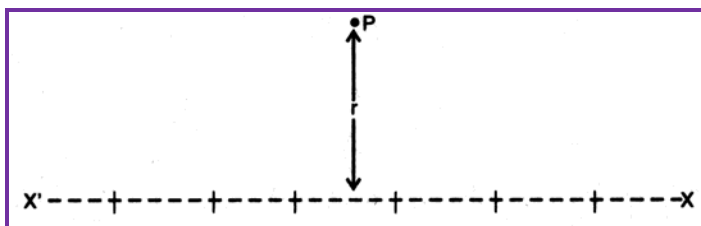
Question: 1

Answer all questions

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

[5]

i.



Explain the statement 'Relative permittivity of water is 81'. Electric field intensity 'E' at a point P at a perpendicular distance 'r' from an infinitely long line charge XX' having linear charge density λ is given by :

☐ $E = \left(\frac{1}{4\pi\epsilon_0} \right) \frac{2\lambda}{r^2}$

☐ $E = \left(\frac{1}{4\pi\epsilon_0} \right) \frac{2\lambda}{r}$

☐ $E = \left(\frac{1}{4\pi\epsilon_0} \right) \frac{\lambda}{r^2}$

☐ $E = \left(\frac{1}{4\pi\epsilon_0} \right) \frac{\lambda}{r}$

Answer: $E = \left(\frac{1}{4\pi\epsilon_0} \right) \frac{\lambda}{r}$

ii. A moving coil galvanometer can be converted into a voltmeter by connecting:

- ☐ A low resistance in series with its coil
- ☐ A low resistance in parallel with its coil
- ☐ A high resistance in series with its coil

Answer: A high resistance in series with its coil

iii. Find the loss of power in a transformer can be reduced by:

- ☐ Increasing the number of turns in primary
- ☐ Increasing ac voltage applied to primary
- ☐ Using a solid core made of steel.
- ☐ Using a laminated core of soft iron.

Answer: Using a laminated core of soft iron.



iv. Which equation represents the emission of a beta particle by a radioactive nucleus:

- ☐ ${}_0^1\text{n} \rightarrow {}_1^1\text{H} + {}_{-1}^0\text{e} + \bar{\nu}$
- ☐ $\gamma \rightarrow {}_0^1\text{e} + {}_{-1}^0\text{e}$
- ☐ $4{}_1^1\text{H} \rightarrow {}_2^4\text{He} + 2{}_1^0\text{e}$
- ☐ ${}_2^4\text{He} + {}_7^{14}\text{N} \rightarrow {}_8^{17}\text{O} + {}_1^1\text{H}$

Answer: $\gamma \rightarrow {}_0^1\text{e} + {}_{-1}^0\text{e}$

v. An important component of Michelson's method to determine speed of light is:

- ☐ A NICOL prism
- ☐ A grating
- ☐ A bi prism
- ☐ An octagonal mirror

Answer: A grating

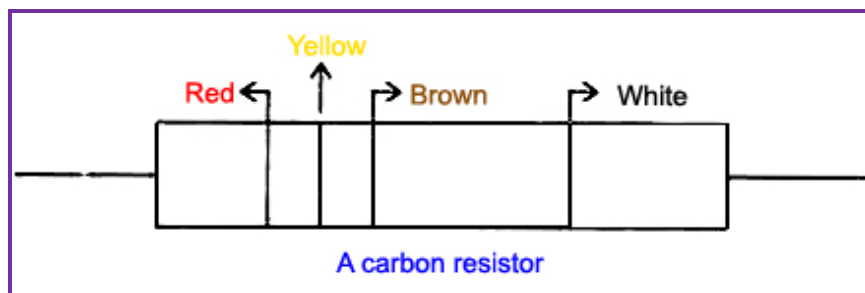
B. Answer all questions briefly and to the point:

[15]

i. In an electric dipole, what is the locus of a point of zero potential?

Answer:
Equatorial position.

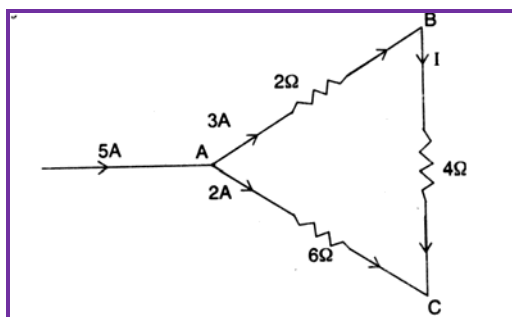
ii. What is the resistance of a carbon resistor whose colored bands are shown below in:



Answer:
240Ω

iii. A part of an electric circuit is shown below:





Using Kirchhoff's 2nd Law, find the current I flowing through the 4Ω resistor.

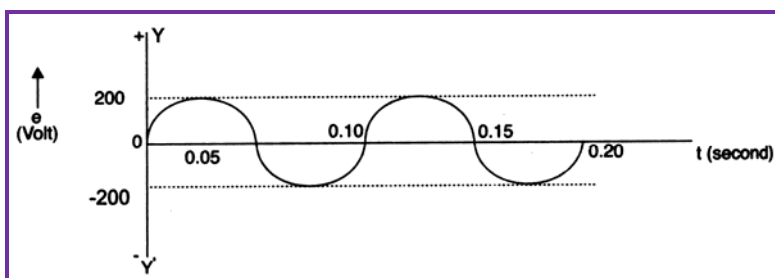
Answer:

In closed mesh ABCA

$$6 + 4i - 12 = 0$$

$$i = 1.5 \text{ amp}$$

iv. The figure below shows a graph of emf ' e ' generated by an AC generator versus time ' t '.



What is the frequency of the emf?

Answer:

Time period = 0.10

$$\text{So, frequency} = \frac{1}{0.10} = 10 \text{ hz}$$

v. Arrange the three types of magnetic materials, i.e. Paramagnetic, diamagnetic and ferromagnetic materials, in decreasing order of their magnetic susceptibility.

Answer:

See topics on 'Properties of dia, para and ferromagnetic substances'.

vi. Which electromagnetic wave is longer than X ray but shorter than light wave?

Answer:

u-v

vii. Calculate the critical angle for glass and water pair. (The refractive index for glass is 1.50 and the refractive index for water is 1.33).

Answer:

$$w\mu_8 = \frac{1.5}{1.3}$$



$$\mu \frac{1}{\sin i_c}$$

$$\sin i_c = \frac{1}{1.5/1.3} = 0.86$$

$$i_c = 60.07^\circ$$

viii. Name an optical device, which, when used with a spectrometer, can determine the wavelength of the given monochromatic light.

Answer:

Prism

ix. Young's double slit experiment was performed, with monochromatic light of blue color. The experiment was then repeated, first with light of red color and then with light of yellow color. Which color produces interference pattern with maximum fringe separation (i.e. fringe width)

Answer:

$$w = \frac{D\lambda}{d}$$

So, maximum fringe separation with red light.

x. Calculate dispersive power of glass, accurately up to three decimal places, from the following data:

Refractive index of glass for red color = 1.60

Refractive index of glass for yellow color = 1.61

Refractive index of glass for violet color = 1.62

Answer:

$$w = \frac{n_v - n_r}{n_y - 1}$$

$$= \frac{1.62 - 1.60}{1.61 - 1}$$

$$= 0.0327$$

xi. De Broglie wavelength of electrons of kinetic energy E is λ . What will be its value if kinetic energy of electrons is made $4E$.

Answer:

$$\lambda = \frac{h}{\sqrt{2mK}}$$

$$\therefore \frac{\lambda'}{\lambda} = \frac{\frac{h}{\sqrt{2m \times 4E}}}{\frac{h}{\sqrt{2mE}}}$$

$$\text{or, } \frac{\lambda'}{\lambda} = \frac{1}{2}$$

$$\text{or, } \lambda' = \frac{\lambda}{2}$$



xii. How much energy will be created if 1 g of matter is destroyed completely?

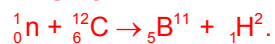
Answer:

$$E = mc^2$$

$$= 1 \times 10^{-3} \times (3 \times 10^8)^2$$

xiii. Complete the following nuclear reaction: ${}_0^1\text{n} + {}_6^{12}\text{C} + {}_5^{11}\text{B} + \dots$

Answer:



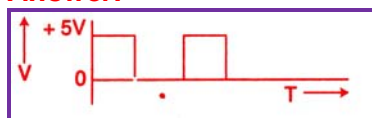
xiv. State one important use of Zener diode.

Answer:

See topics on 'zener'.

xv. Draw a labeled graph of voltage versus time for a signal voltage used in digital circuits.

Answer:



Part: II

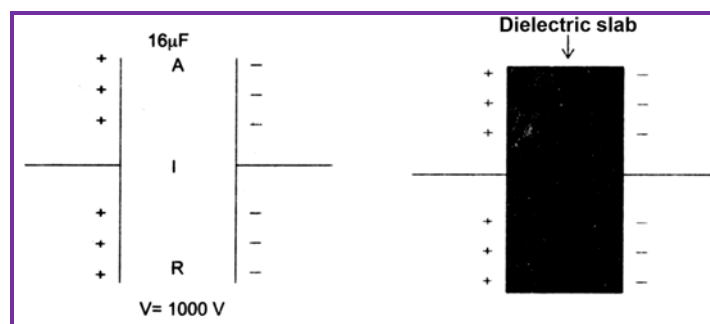
Answer six questions in this part, choosing two questions from each of the Sections A, B and C

Section: A

Question: 2

- i. An isolated $16\mu\text{F}$ parallel plate air capacitor has a potential difference of 1000V . A dielectric slab having relative permittivity (i.e. dielectric constant) = 5 is introduced to fill the space between the two plates completely. Calculate,

[2]



- a. The new capacitance of the capacitor.

Answer:

Given, $C = 16\mu\text{F}$, $V = 1000\text{V}$



We also know,

$$C = \frac{\epsilon_0 A}{d}, \text{ then}$$

$$16 \times 10^{-6} = \frac{8.85 \times 10^{-12} \times A}{d}$$

$$\text{So, } \frac{A}{d} = 1.81 \times 10^6$$

After dielectric is filled,

$$C = \frac{K \epsilon_0 A}{d}$$

$$= 5 \times 8.85 \times 10^{-12} \times 1.81 \times 10^6$$

$$= 80 \times 10^{-6}$$

$$F = 80 \mu F.$$

b. The new potential difference between the two plates of the capacitor.

Answer:

$$V = \frac{V_0}{K}$$

$$= \frac{1000}{5}$$

$$= 200V$$

ii. An electron revolves around the nucleus of hydrogen atom in a circular orbit of radius 5×10^{-11} m. Calculate: [4]

a. Intensity of electric field of the nucleus at the position of the electron.

Answer:

Given,

$$q = 1.6 \times 10^{-19} \text{ C}$$

$$r = 5 \times 10^{-11} \text{ m.}$$

$$E = \frac{1}{4\pi \epsilon_0} \cdot \frac{q}{r^2}$$

$$= \frac{9 \times 10^9 \times 1.6 \times 10^{-19}}{(5 \times 10^{-11})^2} \times 5.76 \times 10^{11} \text{ N/C}$$

b. Electrostatic potential energy of the hydrogen nucleus and electron system.

Answer:

We know

$$U = \frac{1}{4\pi \epsilon_0} \cdot \frac{q_1 q_2}{r}$$

$$= \frac{9 \times 10^9 \times (1.6 \times 10^{-19})^2}{5 \times 10^{-11}} \times 4.608 \times 10^{-18} \text{ J}$$

iii.

[3]



- a. What is Peltier effect? State one difference between Peltier effect and Seebeck effect.

Answer:

See topics on 'Peltier effect'.

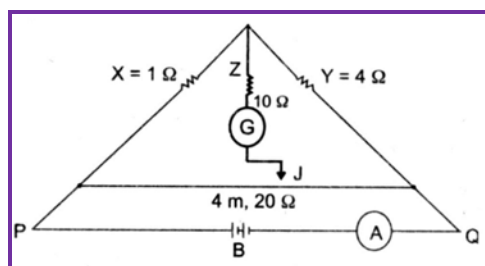
- b. Explain the statement. 'Temperature coefficient of resistance of a metal is $4 \times \frac{10^{-3}}{^{\circ}\text{C}}$ '

Answer:

This means that for every 1°C rise in temperature its resistance increases by 4×10^{-3} ohm.

Question: 3

- i. In the circuit shown below, PQ is a uniform metallic wire of length 4m and resistance 20Ω . Battery B has an e.m.f of 10V and internal resistance of 1Ω . J is a jockey or slide contact. Resistance of the ammeter A and connecting wires is negligible. [4]



- a. When the jockey J does not touch the wire PQ, what is the reading of ammeter A?

Answer:

Total resistance = 5Ω

$$i = \frac{E}{R + r} = \frac{10}{5 + 1} = \frac{10}{6} = 1.66 \text{ amp.}$$

- b. Where should be jockey J be pressed on the wire PQ so that the galvanometer G shows no deflection?

Answer:

We know by Wheatstone's balance condition,

$$\frac{P}{Q} = \frac{R}{S},$$

$$\frac{1}{4} = \frac{R}{S}$$

Dividing 20Ω in the ratio of 1:4 is 4Ω and 16Ω

$20 \text{ ohm} = 4 \text{ m}$

$$\text{So, } 4 \text{ ohm} = \frac{4 \times 4}{20}.$$



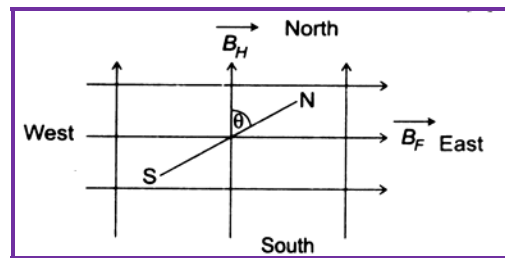
- ii. What is 'current density'? Write the vector equation connecting current density \vec{J} with electric field intensity \vec{E} , for an ohmic conductor. [2]

Answer:

Current density: It is defined as the ratio of the current at that point in the conductor to the area of cross section of the conductor at that point.

Vector equation: $\vec{J} = \sigma \vec{E}$

- iii. A small magnetic needle NS having magnetic dipole moment \vec{P}_m is kept in two uniform and perpendicular magnetic fields \vec{B}_F and \vec{B}_H as shown below: [2]



- a. What is the effect of each of the magnetic fields \vec{B}_F and \vec{B}_H on the needle?

Answer:

Because of B_H and B_F it experiences torques exerted by these two fields.

- b. When the needle is in equilibrium obtain an expression for angle θ made by the needle with \vec{B}_H in terms of \vec{B}_F and \vec{B}_H only.

Answer:

$$MB_H \sin \theta = MB_F \cos \theta$$

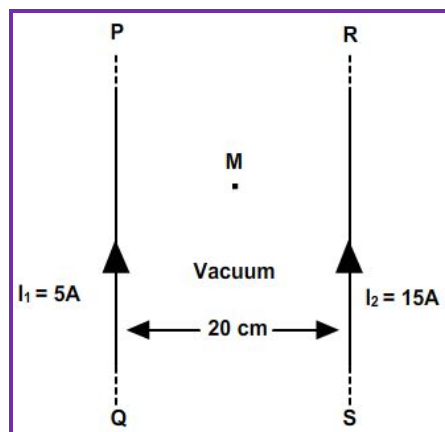
$$B_F = B_H \tan \theta.$$

Question: 4

[3]

- a. Figure below shows two very long conductors PQ and RS kept parallel to each other in vacuum at a distance of 20cm. They carry currents of 5A and 15A respectively, in the same direction as shown. Find the resultant magnetic flux density \vec{B}_R at a point M which lies exactly midway between PQ and RS.





Answer:

We know magnetic field $B = \frac{\mu_0 i}{2\pi R}$

$$\text{So, } B_1 = \frac{\mu_0 i_1}{2\pi R_1}$$

$$= \frac{2 \times 10^{-7} \times 5}{10}$$

$= 1 \times 10^{-7}$, direction is vertically downward

$$B_2 = \frac{\mu_0 i_2}{2\pi R_2}$$

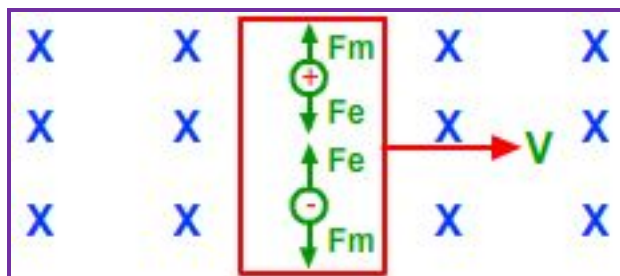
$$= \frac{2 \times 10^{-7} \times 15}{10}$$

$= 3 \times 10^{-7}$ T , direction is vertically upward.

- b. With the help of a neatly drawn labeled diagram, prove that the magnitude of motional emf 'e' is given by $e = Blv$, where 'l' is the length of a metallic rod and 'v' is the velocity with which it is pulled in a transverse magnetic field 'B'. [3]

Answer:

Let a conducting rod of length l is taken placed in the magnetic field \perp to the plane of the paper directed downward. As the rod is moving so charge contained inside is also moving. As the rod is moving so charge contained inside is also moving. So force acting on it is given by, $F_m = qVB$.



According to Fleming's left hand rule magnetic force is acting upward on positive charge whereas a negative charge it is downward. So the pot, difference induced b/w the ends of the rod is V so electric field is given by



$$E = V/l \dots\dots\dots(i)$$

Electric force is given by, $F_e = qE$

The magnitude of electric force goes on increasing till it becomes equal to F_m . When, $F_m = F_e$ the movements of e^- stops.

$$F_e = fm$$

$$qE = qvB$$

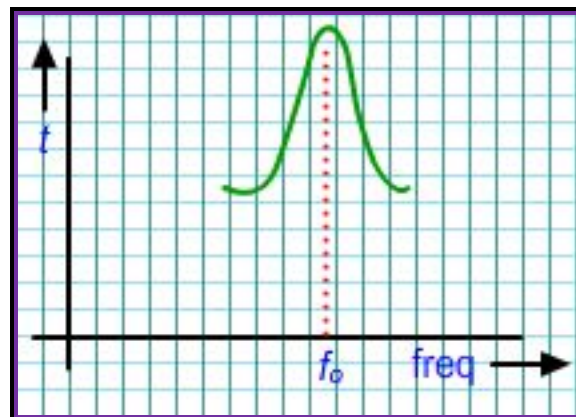
$$E = Bv \dots\dots\dots(ii)$$

On comparing (i) and (ii) we see that

$$\frac{V}{l} = Bv$$

- c. Plot a labeled graph showing variation in impedance Z of a series LCR circuit with frequency f of alternating emf applied to it. What is the minimum value of this impedance? [3]

Answer:



Minimum value of impedance = resistance

Section: B

Question: 5

- i. On the basis of Huygens's wave theory, show that when light is incident on a plane mirror obliquely, angle of reflection is equal to the angle of incidence: [3]

Answer:

See topics on 'Huygens' principle'

ii.

- a. What is a continuous emission spectrum? Name one source of light which produces such a spectrum. [3]



Answer:

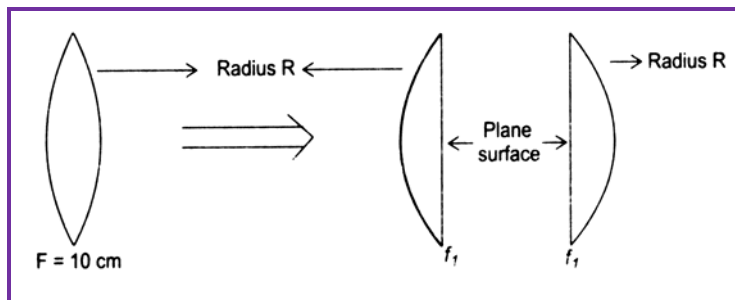
See topics on 'emission spectrum'.

- b. Explain in brief why dark lines are observed in the solar spectrum.

Answer:

See topics on 'solar spectra and Fraunhofer lines spectra'.

- iii. An equi-convex lens of glass, having focal length of 10cm is split into two identical plano-convex lens each having focal length f_1 as shown below: Find the value of f_1 . [3]

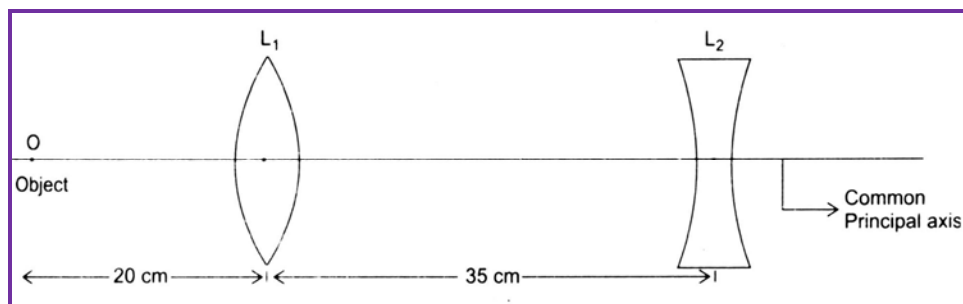


Answer:

As the lens is split into two identical plano convex lens so their power becomes half and focal length will become double i.e. 20 m each.

Question: 6

- i. An illuminated point object O is kept 20cm from a thin convex lens L_1 of focal length 15cm as shown below. A thin diverging lens L_2 of focal length 25cm is kept co-axial with the first lens and 35cm from it, as shown in. [3]



Find the position of the final image formed by this combination of lenses.

Answer:

We know by lens formula

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

$$\frac{1}{v} + \frac{1}{20} = \frac{1}{15}$$

$$\frac{1}{v} = \frac{1}{15} - \frac{1}{20} = \frac{1}{60}$$

$$v = 60 \text{ cm}$$



For convex lens $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$$\frac{1}{v} - \frac{1}{25} = -\frac{1}{25}$$

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

$$v = \infty$$

So the final image will be formed at infinity.

ii. Give any two methods by which (ordinary) light can be polarized.

[2]

a. What are coherent sources?

Answer:

The sources of light which have a constant phase difference with time is called coherent sources.

b. In Young's double slit experiment, what is the path difference between the two light waves forming 5th bright band (fringe) on the screen?

Answer:

$$X = m\lambda$$

Have $m = 5$

So, path difference = 5λ

iii. State one similarity and one difference between interference of light and diffraction of light.

Answer:

Similarity

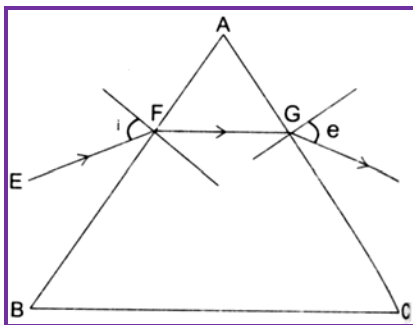
In interference and diffraction both the fringes are observed.

Difference

Interference is due to superposition of light whereas diffraction is due to interference of secondary wavelength coming from different points of same wave front.

Question: 7

i.



A ray EF of monochromatic light is incident on the refracting surface AB of a regular glass prism (refractive index = 1.5) at an angle of incidence of $i = 55^\circ$. If it emerges through the adjacent face AC, calculate the angle of emergence 'e'. [3]



Answer:

$$n = \frac{\sin i}{\sin r}$$

$$1.5 = \frac{\sin 55^\circ}{\sin r} \quad r = 33.0^\circ$$

By geometry: $r' = 27^\circ$ $n = \frac{\sin i}{\sin r}$

$$\frac{1}{1.5} = \frac{\sin 27^\circ}{\sin e}$$

$$e = 42.9^\circ$$

ii.

[2]

- a. In case of polarized light, what is meant by the 'plane of polarization'?

Answer:

Plane containing the direction of propagation of light and perpendicular to the plane of vibration is called plane of polarization.

- b. Find refractive index of glass if its polarizing angle of 60° .

Answer:

$$\mu = \tan i_p = \tan 60^\circ = \sqrt{3} = 1.732.$$

iii.

[3]

- a. Explain the statement: "Angular magnification of a compound microscope in normal use is 30."

Answer:

Angular magnification is 30 means that the image formed will be 30 times bigger than the object.

- b. State how the resolving power of an astronomical telescope can be increased.

Answer:

Resolving power of an astronomical telescope can be increased by increasing the diameter of the aperture.

Section: C

Question: 8

- i. In Millikan's oil drop experiment, the two plates are 2cm apart. When a potential difference of 2355V is applied between them, an oil drop of radius $1\mu\text{m}$ is found to remain suspended. Calculate the number of excess electrons on the drop. [Density of oil = 900 kg/m^3 . Density of air may be ignored]

[3]



Answer:

$$qE = \frac{4}{3} \pi r^3 (\rho - \sigma)g$$

$$q = \frac{4}{3} \pi r^3 \frac{(\rho - \sigma)g}{E} \text{ but } E = V/d$$

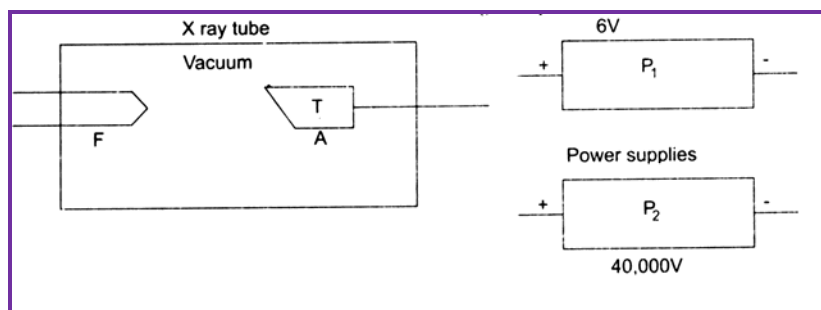
$$= \frac{4 \times 3.14 \times (1 \times 10^{-6})^3 \times 900 \times 10 \times 2 \times 10^{-2}}{3 \times 2355}$$

$$= 3.2 \times 10^{-19} \text{ C}$$

$$q = ne$$

$$\text{But, } 3.2 \times 10^{-19} = n \times 10^{-19} \quad n = 2.$$

- ii. Figure below shows a simple X ray tube, P_1 and P_2 are power supplies which generate 6V and 40,000 respectively. Show how you will connect these power supplies to the X ray tube so that it starts producing X rays. [2]



Answer:

6V to the filament 40,000 V to anode and cathode.

iii.

- a. Write a balanced equation showing nuclear fission of Uranium (${}_{92}^{235}\text{U}$)

Answer:



- b. In a nuclear reactor, what is the function of:

- Cadmium rods?
- Graphite rods?

Answer:

Cadmium rods: They are used as controlling rods.

Graphite rods: They are used as moderator.



Question: 9

- i. Starting with $N = N_0 e^{-\lambda t}$, obtain a relation between disintegration constant ' λ ' of a radioactive element and its half-life (T). Various terms have their usual meaning. [2]

Answer:

See topics on 'half-life (T) and decay constant (λ)'.

- ii. On an energy level diagram of hydrogen, show by a downward or an upward arrow, a transition which results in: [3]
- Emission line of Balmer series.
 - Emission line of Lyman series
 - Absorption line of Lyman series

Answer:

See topics on 'Hydrogen spectrum'.

- iii. Calculate:
- Mass defect of Helium (${}^4_2\text{He}$) nucleus and
 - Its binding energy in MeV.

Mass of proton = 1.007276μ
Mass of neutron = 1.008665μ
Mass of ${}^4_2\text{He}$ nucleus = 4.001506μ

Answer:

a. Mass defect
= mass of nucleons – mass of nucleus
= $(2 \times 1.007276 + 2 \times 1.008665) - 4.001506$
= $(2.014552 + 2.01733) - 4.001506$
= 0.0303764

b. Binding Energy
= 0.030376×931.5
= 28.295 MeV

Question: 10

- i. Draw a neatly labeled diagram of a common emitter amplifier. What is the phase angle between the input and output voltage? [3]

Answer:

See topics on 'common emitter amplifier'.

- ii. Threshold wavelength of a certain metal is 792nm . What is the maximum kinetic energy of photo-electrons emitted by this metal if it is exposed to ultraviolet light of wavelength 396nm ? [3]

Answer:

Given, $\lambda_0 = 792\text{nm}$, $\lambda = 396 \text{ nm}$.



We know, $\omega = \frac{hc}{\lambda_0}$

$$= \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{792 \times 10^{-9} \text{ J}}$$

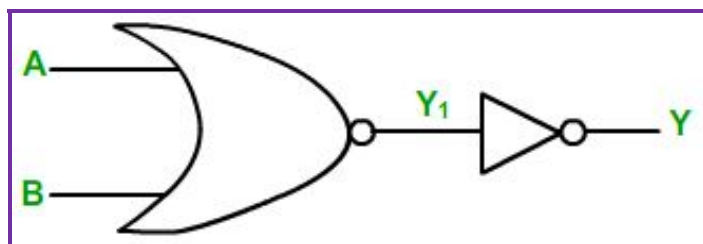
We also know, $\omega = E_K$

$$= \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{396 \times 10^{-9}}$$

$$= 2.5 \times 10^{-19} E_K$$

$$E_K = 2.5 \times 10^{-19} \text{ J} = 1.562 \text{ eV}.$$

- iii. The following combination of gates acts as a logic gate. With the help of a truth table, find out which logic gate the combination represents: [2]



Uses of Constants and Relations:		
1.	Speed of Light in vacuum	(c) = $3.0 \times 10^8 \text{ ms}^{-1}$
2.	Charge of a proton	(e) = $1.6 \times 10^{-19} \text{ C}$
3.	Planck's constant	(h) = $6.6 \times 10^{-34} \text{ Js}$
4.	Acceleration due to gravity	(g) = 10 ms^{-2}
5.	Constant of proportionality for Coulomb's Law	$\left(\frac{1}{4\pi\epsilon_0} \right) = 9 \times 10^9 \text{ mF}^{-1}$
6.	Constant of proportionality for Biot-Savart Law	$\left(\frac{\mu_0}{4\pi} \right) = 10^{-7} \text{ Hm}^{-1}$
7.	Electron Volt	$1\text{eV} = 1.6 \times 10^{-19} \text{ J}$
8.	Unified Atomic Mass Unit	$1\text{u} = 9.31 \text{ MeV}$ (π) = 3.14

Answer:

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

