SRS PU COLLEGE, CHITRADURGA

(in coordination with Narayana Group of Institutions, Hyderabad)

II PU PHYSICS ANNUAL EXAM - MARCH 2020

SUBJECT: PHYSICS (33) **Max. Marks-70**

INSTRUCTIONS **Time: 3.15 Hrs**

This question paper has 4 parts, all parts are compulsory.

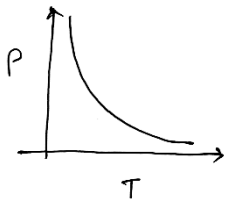
- **Part-A carries 10 marks. Each question carries one mark.**
- **Part-B carries 10 marks. Each question carries two marks.**
- **Part-C carries 15 marks. Each question carries three marks.**
- **Part-D carries 35 marks. Each question carries five marks.**

PART-A

I. Answer all the questions. Each question carries one mark

1. **Write the SI unit of electric flux.**
   Ans: $\frac{N-m^2}{C}$ or $V-m$

2. **Graphically represent the variation of resistivity of a semiconductor with absolute temperature.**
   Ans:



3. **Give any one use of electromagnet.**
   Ans: Loud speaker, Crane, electric bell.

4. **What is the significance of LenZ's law?**
   Ans: Law of conservation of energy, it gives direction of induced current.

5. **How does capacitive reactance vary with frequency?**
   Ans: $X_c \propto \frac{1}{f}$

6. **Arrange the following electromagnetic waves in ascending order of their wavelength:**
   Radio waves, Gamma rays, Infrared waves, X-rays
   Ans: $\gamma - rays > x - rays > IR >$ Radio waves

7. **Why does sky appear blue?**
   Ans: Scattering of light

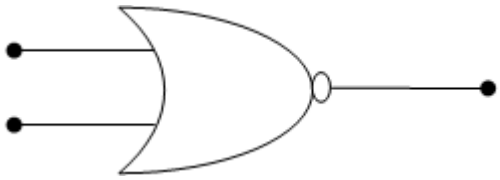
8. **Mention a method to increase the resolving power of a microscope.**
   Ans: Decreasing wave length, increasing refractive index

9. **Write the nuclear reaction equation for alpha decay of $^{238}_{92}U$**

Ans: $_{92}U^{238} \rightarrow {}_{90}Th^{234} + {}_{2}He^{4} + Q$

10. **Draw the logic symbol of NOR gate.**

Ans:



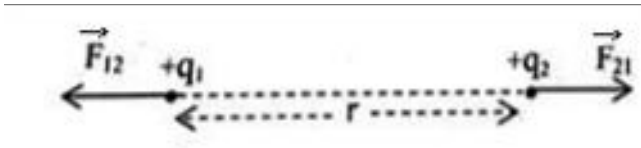
PART-B

II. Answer any five of the following questions.

11. **State and explain Coulomb's law in electrostatics.**

Ans:

"The electrostatic force of attraction or repulsion between two static point charges in free space is directly proportional to the product of the magnitude of charges and inversely proportional to the square of the distance between them".



If F is the force between two point charges q_1 and q_2 at a distance r apart then

$$F \propto \frac{q_1 q_2}{r^2}$$

$$F = K\left(\frac{q_1 q_2}{r^2}\right)$$

Where K is proportionality constant.

For air or vacuum

$$K = \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 Nm^2C^{-2}$$

$$\therefore F = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1 q_2}{r^2}\right),$$

Where ε_0 is permittivity of free space

$= 8.854 \times 10^{-12}$ F/m.

12. **A parallel plate capacitor with air between the plates has capacitance C. What will be the capacitance if**

a) the distance between the plates is doubled?

b) the space between the plates is filled with a substance of dielectric constatnt 5?

Ans: a) Capacitance becomes half $\left(\frac{C}{2}\right)$

b) Capacitance becomes five times $(5C)$

13. **Write two limitations of Ohm's law.**

Ans: Limitations of Ohm's law are

1) Ohm's law is applicable only for conductors at constant temperature.

2) Ohm's law holds good only if all physical conditions remain the same.

14. **In a region, an electric field $\vec{E} = 5 \times 10^3 \hat{j}\ NC^{-1}$ and a magnetic field of $\vec{B} = 0.1\ \hat{K}T$ are applied. A beam of charged particles are projected along X-direction. Find the velocity of charged particles which move un deflected in this crossed fields**

Ans: $V = \frac{E}{B}$

$$V = \left(\frac{5\times10^3}{0.1}\right)$$

$$V = 5 \times 10^4\ ms^{-1}$$

15. **Define "retentivity" and "coercivity"**

Ans:

The property of a ferromagnetic substance to retain the magnetism even after making magnetising field zero is called retentivity.

The property of ferromagnetic substance to get demagnetised in the presence of a reverse magnetising field is called coercivity.

16. **Mention two sources of energy loss in transformer.**

Ans:

a) Loss due to heating of coils.

b) Loss due to flux leakage.

17. **What is displacement current? Give the expression for it.**

Ans:

Current that result due to the time rate of change of electric flux is called displacement current.

Displacement current $I_d = \varepsilon_0 \frac{d\phi_E}{dt}$

ε_0 = permittivity of free space, $\frac{d\phi_E}{dt}$ =rate of change of electric flux

18. **An alpha particle, a proton and an electron are moving with equal kinetic energy. Which one of these particles has the longest de Broglie wavelength? Give reason.**

Ans: $\lambda = \frac{h}{\sqrt{2mE}}$, $\lambda \propto \frac{1}{\sqrt{m}}$

$m_\alpha > m_p > m_e$

$\lambda_e > \lambda_p > \lambda_\alpha$

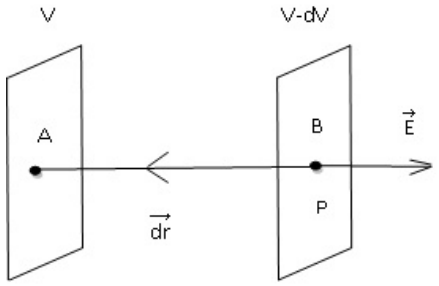
∴ electron has longer wavelength, because of smaller mass.

PART-C

III. Answer any five of the following questions.

19. Establish the relation between electric field and electric potential.

Ans:



Consider two closely spaced equipotential surfaces A and B with potential values V and V-dV. Let P be a point on the surface B and dr be the perpendicular distance of the surface A from P. Workdone in moving unit positive charge from B to A against electric field is

$dW = \vec{E}.\vec{dr} = E\,dr\cos\theta$

$$dW = Edr\cos 180^{\circ}$$

$$dW = -Edr \ldots\ldots\ldots\ldots (1)$$

This work done is equal to potential difference between the surfaces A and B.

$$\therefore dW = V_A - V_B$$

$$= V - (V - dV)$$

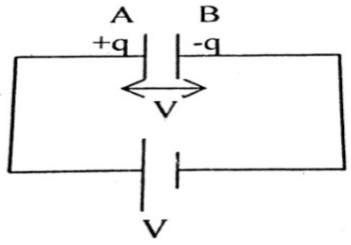
$$dW = dV \ldots\ldots\ldots (2)$$

$$\therefore dW = -E\,dr$$

$$E = -\frac{dV}{dr}$$

20. Derive the expression for energy stored in charged capacitor.

Ans:



The workdone in charging the capacitor by battery is stored as energy in capacitor.

Consider a capacitor of capacity C

connected to a battery. During the process of charging Let q be the charge and V′ be the p.d between the plates of the capacitor at an instant of time t.

Then $q = CV'$ or $V' = \frac{q}{c} - - - (1)$

The work done by the battery in transferring a small quantity of charge dq is given by

$dW = V'\,dq = \left(\frac{q}{C}\right)dq$ From (1)

∴ Total work done in charging the capacitor to a charge Q is

$W = \int_0^Q dW = \int_0^Q \frac{q}{C} dq = \frac{1}{C}\int_0^Q q\,dq$

$W = \frac{1}{C}\left[\frac{q^2}{2}\right]_0^Q \quad \therefore \int x\,dx = \frac{x^2}{2}$

$W = \frac{1}{C}\left[\frac{Q^2}{2} - 0\right]$

$W = \frac{Q^2}{2C}$

This work done is stored as energy of capacitor $U = \frac{Q^2}{2C}$

Also $U = \frac{1}{2}CV^2 = \frac{1}{2}\left(\frac{Q^2}{C}\right) = \frac{1}{2}QV$

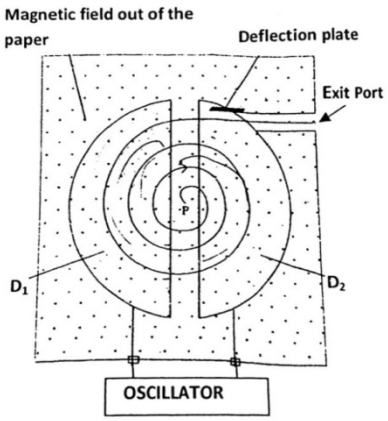
21. Give the principle of cyclotron and draw the neat labelled schematic diagram of cyclotron.

Ans:

Principle:

1.Time period of revolution of charged particle is independent of radius of circular path and velocity of charged particle

2.Charged particle moving normal to a magnetic field experiences force due to which the particle moves in circular path



22. Mention three properties of diamagnetic materials.

Ans:

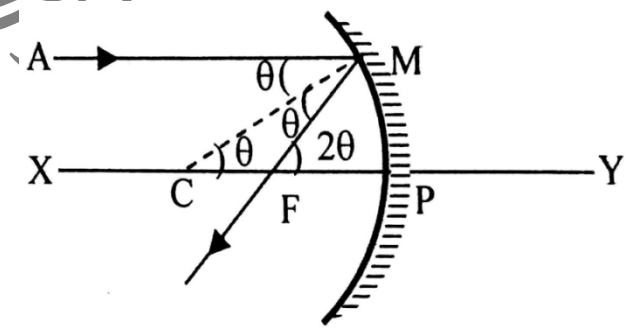
i) When a diamagnetic substance is placed in magnetic field, Magnetic field lines inside the material are slightly lesser than that in air.($\mu < \boldsymbol{\mu}_0$).

ii) In non-uniform magnetic field they tend to move form stronger to weaker region of the field.

iii) These substances are weakly repelled by a strong magnet**.**

23. Arrive at the relation between focal length and radius of curvature of a spherical concave mirror.

Ans:



Let us consider a concave mirror of pole P,center of curvature C and focus F.Let the focal length f and radius of curvature R.

AM is incident ray,MF is reflected ray and MC is normal

From ΔMCP, $\tan\theta = \frac{MP}{CP}$

from ΔMFP, $\tan 2\theta = \frac{MP}{FP}$

Since θ is very small $\tan\theta \approx \theta$ and

$\tan 2\theta \approx 2\theta$

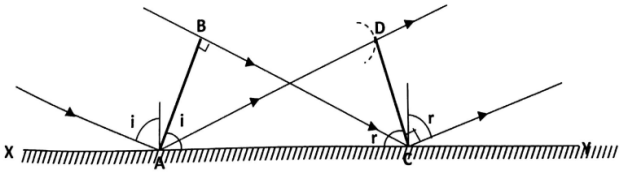
$\therefore \theta = \frac{MP}{CP}$ and $2\theta = \frac{MP}{FP}$ or $\theta = \frac{MP}{2FP}$

$\therefore CP = 2FP \ \therefore R = 2f$ or $f = \frac{R}{2}$

24. Using Huygen's principle, show that the angle of incidence is equal to the angle of reflection when a plane wave front is reflected by plane surface.

Ans:

Consider a plane wavefront AB incident at an angle i on a reflecting surface XY. If v is the speed of the wave in the medium and if t is the time taken by the wavefront to advance from the point B to C then the distance BC = vt



In order to construct the reflected wavefront we draw an arc at D of radius vt with A as centre. The tangent from C touches this arc at D. Hence CD is the reflected wavefront and let r be the angle of reflection. In $\Delta ABC \text{ and } \Delta ADC$, $\angle ABC = \angle CDA = 90^0$,

AD = BC = vt and AC is common. Then triangles ABC and ADC are congruent and therefore, the angles i and r are equal. This is the law of reflection.

25. Define work function. Write Einstein's photoelectric equation and explain the terms.

Ans:

The minimum energy required to liberate an electron from the metal surface is called the work function (Φ_0) of the metal.

$K_{max} = h\nu - \Phi_0$ – – – – – (1)

where ν - frequency of incident radiation, ν_0 - threshold frequency. Φ_0 – work function of the material.

This equation is called Einstein's photoelectric equation,

26. Give three differences between intrinsic and extrinsic semiconductors.

Ans:

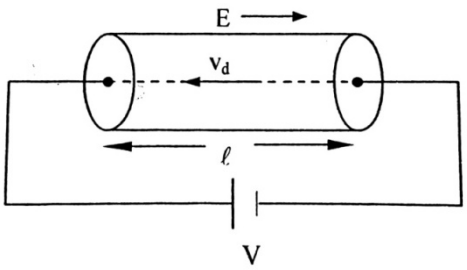
Intrinsic semiconductor	Extrinsic semiconductor
It is a pure semiconductor crystal.	It is a semiconductor doped with impurities
Number of electrons and holes are equal	Number of electrons and holes are unequal
Conductivity depends only on temperature	Conductivity depends on temperature and impurities
Conductivity is due to both electrons and holes.	Conductivity is mainly due to majority charge carriers.

PART-D

IV. Answer any three of the following questions.

27. Derive the expression for conductivity of a material: $\sigma = \frac{ne^2\tau}{m}$; Where the terms have their usual meaning.

Ans:



Consider a conductor of length *l* and area of cross section A. Let a p.d. of V be applied across its ends.

Then drift velocity is

$v_d = a\tau = \frac{Ee\tau}{m}$ – – – – – (1)

Current flowing through the conductor is $I = nAeV_d$ – – – (2)

n→number of free electrons per unit volume

e→charge on an electron,

Sub(1) in (2), i.e, $I = nAe\left(\frac{Ee\tau}{m}\right) = \left(\frac{n\,A\,e^2\,\tau}{m}\right)E$ or $\frac{I}{A} = \left(\frac{ne^2\tau}{m}\right)E$.

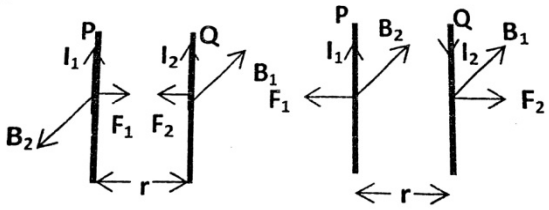
$$J = \left(\frac{ne^2\tau}{m}\right)E$$

$\therefore \sigma E = \left(\frac{ne^2\tau}{m}\right)E. \quad (J = \sigma E)$

$$\therefore \sigma = \left(\frac{ne^2\tau}{m}\right).$$

28. Obtain the expression for the force between two straight long parallel conductors carrying current. Hence define "ampere".

Ans:



Let P and Q be two long straight parallel conductors carrying currents I_1 and I_2 in the same direction. Let r be the distance between the two conductors. The magnetic field at any point on Q due to the current in p is,

$$B_1 = \frac{\mu_0 I_1}{2\pi r} \text{ ------(1)}$$

Due to this magnetic field, the conductor Q experiences a mechanical force which is given by

$$F_2 = B_1 I_2 L \sin\theta$$

where L is the length of the conductor.

$$F_2 = B_1 I_2 L \qquad \because \theta = 90^0$$

$F_2 = \frac{\mu_0 I_1 I_2 L}{2\pi r}$ [from (1)]-------(2)

Similarly force experienced by P due to the magnetic field by Q is

$F_1 = \frac{\mu_0 I_1 I_2 L}{2\pi r}$ -----(3)

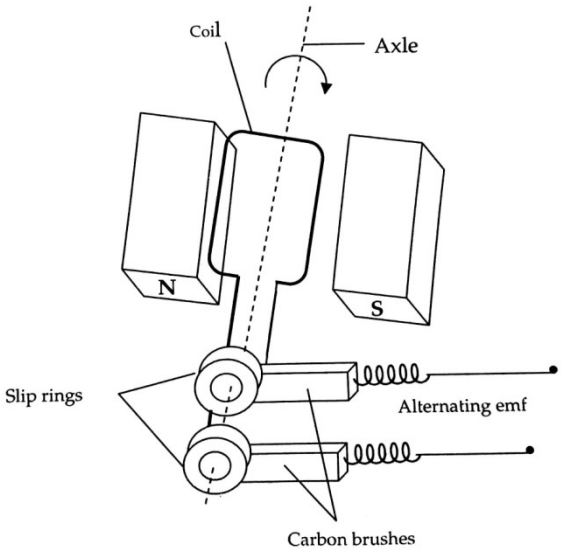
From equation (2) and (3), $F_1 = F_2$

∴ Force per unit length of the conductor is $F = \frac{F_1}{L} = \frac{F_2}{L} = \frac{\mu_0 I_1 I_2}{2\pi r}$

One ampere is defined as that steady current which when maintained through two infinitely long straight parallel conductors placed one metre apart in free space exerts a force of 2×10^{-7} Newton per metre length on each other.

29. With the help of labelled diagram, derive the expression for instantaneous *emf* induced in an AC generator.

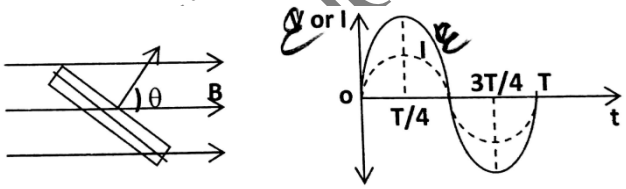
Ans:



Consider a rectangular coil of 'N' turns and area 'A' which is rotated in a uniform magnetic field of flux density B with a uniform angular velocity ω. Initially, let the plane of the coil be perpendicular to the applied magnetic field.

Let θ be the angle made by the coil in time 't' as shown in the fig.

We have, $\omega = \frac{\theta}{t}$ or $\theta = \omega t$.



The flux linked with the coil is given by,

$\emptyset = NAB\cos\theta \quad \therefore \emptyset = NAB\cos\omega t - - - (1)$

By Faraday's law induced emf given by,

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

$\varepsilon = -\frac{d}{dt}(NA\,B\cos\omega t)$ [from (1)]

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

$\varepsilon = NAB\omega \sin\omega t$

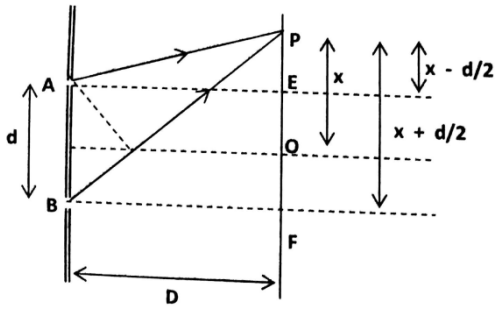
$\varepsilon = \varepsilon_0 sin\omega t - - - -(2)$

Where $\varepsilon_0 = NAB\omega$ is the peak voltage.

V. Answer any TWO of the following questions.

30. Obtain the expression for Fringe width of interference fringes in Young's Double slit experiment.

Ans:



Consider two slits A and B seperated by a distance d. Let D be the distance between the slits and the screen. P is a point on the screen at a distance x from 0 (central fringe).

From $\Delta APE, AP^2 = D^2 + \left(x - \frac{d}{2}\right)^2$

Also from $\Delta BPF, BP^2 = D^2 + \left(x + \frac{d}{2}\right)^2$

$BP^2 - AP^2 = \left(x + \frac{d}{2}\right)^2 - \left(x - \frac{d}{2}\right)^2$

$(BP + AP)(BP - AP) = 2xd$

Path difference BP – AP= $\frac{2xd}{BP+AP}$

Since d<<D and P is close to O, BP≅AP≅D

Path difference $\delta = \frac{2Xd}{2D}$

Path difference, $\delta = \frac{xd}{D}$

Condition for constructive interference :

For a bright fringe at P,

$$\delta = \frac{xd}{D} = n\lambda \quad \text{or} \quad x = \frac{D}{d}n\lambda$$

This is the distance of n^{th} bright fringe from O

Similarly distance of (n+1)th bright fringe

$$x_{n+1} = \frac{D}{d}(n + 1)\lambda$$

∴ Distance between two consecutive bright fringes $= x_{n+1} - x_n = \frac{D}{d}(n + 1)\lambda - \frac{D}{d}n\lambda$

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

Condition for destructive interference:

For a dark fringe at P

$$x\frac{d}{D} = (2n - 1)\frac{\lambda}{2}$$

Distance of n^{th} dark fringe from O is

$$x_n = (2n - 1)\frac{\lambda D}{2d}$$

For $(n + 1)^{th}$ dark fringe

$x_{n+1} = [2(n+1)-1]\frac{\lambda D}{2d}$

$x_{n+1} = (2n+1)\frac{\lambda D}{2d}$

Width of dark fringe = $x_{n+1} - x_n$

$=(2n+1)\frac{\lambda D}{2d} - (2n-1)\frac{\lambda D}{2d}$

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

∴ width of bright fringe = width of dark fringe

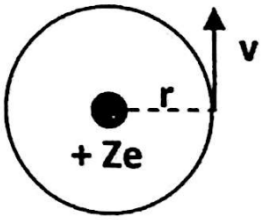
$\beta = \frac{\lambda D}{d}$.

This is the expression for fringe width.

31. Using Bohr's postulates, derive the expression for the radius of n^{th} stationary orbit of electron in hydrogen atom. Hence write the expression for Bohr radius.

Ans:

Consider an electron of mass 'm' and charge of magnitude 'e' revolving around the nucleus of charge Ze. Let r be the radius of the n^{th} orbit and v be the velocity of the electron in this orbit.



According to Bohr's postulate,

Centripetal force = Electrostatic force of attraction between the nucleus and the electron

$$\frac{mv^2}{r} = \frac{1}{4\pi\epsilon_0}\frac{Ze^2}{r^2}$$

$$mv^2r = \frac{Ze^2}{4\pi\epsilon_0} - - - - (1)$$

According to Bohr's postulate, angular momentum of the electron in the n^{th} orbit is

$mvr = n\frac{h}{2\pi}$

Squaring $m^2v^2r^2 = \frac{n^2h^2}{4\pi^2} - - - -(2)$

Eqn (2)/(1), $mr = \frac{n^2h^2}{4\pi^2}\frac{4\pi\epsilon_0}{Ze^2} \Rightarrow r_n = \frac{\varepsilon_0 n^2h^2}{\pi mZe^2}$

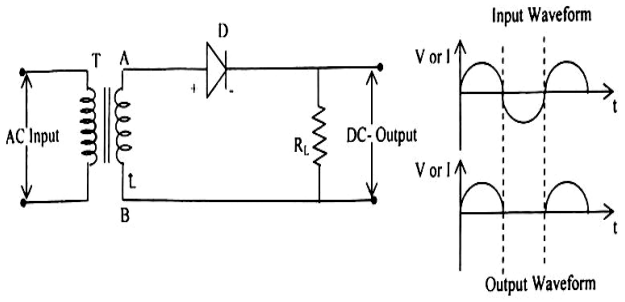
For hydrogen atom Z = 1 ∴ Radius of n^{th} orbit of H-atom is $r_n = \frac{\varepsilon_0 n^2h^2}{\pi me^2}$

Bohr's radius $a_0 = \frac{\varepsilon_0\, h^2}{\pi me^2}$.

32. What is rectification? Explain working of a $p-n$ junction diode as a half wave rectifier. Draw the input and output wave forms.

Ans:

Rectification : The process in which A.C is converted into D.C is called rectification



A rectifier in which current flows only during one half cycle of the input ac is called a half – wave rectifier.

Construction: Half wave rectifier consists of a step – down transformer whose primary is connected to a.c source and secondary is connected to the series combination of p-n junction diode and a load resistance RL as shown in the fig. The output is drawn across load resistance.

Working:

The AC to be rectified is fed into the primary of the transformer, a voltage is induced across the secondary of the transformer .During +ve half cycle of AC input, the diode is forward biased and hence it conducts. But during the – ve half cycle of the AC input, the diode is reverse biased and hence it does not conduct. So the current flowing through the R_L is a rectified output in the form of pulsating DC. The input waveform and output waveform are as shown in the graph.

VI. Answer any THREE of the following questions.

33. Two point charges $q_A = 5\mu C$ and $q_B = 5\mu C$ are located aat A and B separeated by $0.2\ m$ vacuum.

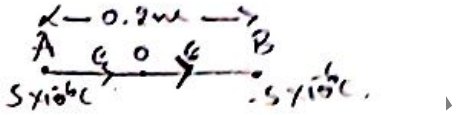
a) What is the electric field at the midpoint 0 of the line joining the charges?

b) If a negative test charges of magnitude $2nC$ is planed at 0, what is the force experienced by the test charge?

Given Charges

$q_A = 5 \times 10^{-6} C.$

$q_B = -5 \times 10^{-6} C.$



a) Electric field, at mid point 'O' is

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

$$= \frac{9\times10^9 \times 5\times10^{-6}\times 2}{(0.1)^2}$$

$$\boxed{E = 9\times10^6\ N/C}$$

b) Force on test charge.

$$F = E \times q$$

$$= 9\times10^6 \times 2\times10^{-9}$$

$$\boxed{F = 18\times10^{-3}\ N.}$$

34. a) Three resistors 3Ω, 4Ω, and 12Ω are connected in parallel. What is the effective resistance of the combination?

b) If the combination is connected to a battery of emf $6V$ and internal resistance 0.5Ω, find the current drown from the battery and terminal potential differance across the battery.

34) Given. Resistors. $R_1 = 3\Omega$, $R_2 = 4\Omega$, $R_3 = 12\Omega$.

a) In parallel $\frac{1}{R_{eff}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$.

$$\frac{1}{R_{eff}} = \frac{1}{3} + \frac{1}{4} + \frac{1}{12}$$

$$\frac{1}{R_{eff}} = \frac{8}{12} \Rightarrow R_{eff} = \frac{12}{8} = \underline{1.5\Omega}$$

b) Current drown from the Battery:

$$I = \frac{E}{R+r}.$$

$$= \frac{6}{1.5 + 0.5}$$

$$= \frac{6}{2}$$

$$\boxed{I = 3A}$$

Terminal P.D. $= V = E - Ir$.

$$= 6 - 3 \times 0.5$$

$$= 6 - 1.5$$

$$\boxed{V = 4.5\,V}.$$

35. A series LCR circuit contains a pure inductor of inductance $5.0H$, a capacitor of capacitance $20\mu F$ and a resistor 40Ω.

a) Find the resonant frequency of the circuit.

b) Calculate the quality factor $(Q-factor)$ of the circuit.

c) What is the impedance at resonant condition.

Given. $L = 5H$, $C = 20\times10^{-6}F$, $R = 40\Omega$

a) Resonant frequency $(f) = \frac{1}{2\pi\sqrt{LC}}$.

$$= \frac{1}{2\times3.14\sqrt{5\times20\times10^{-6}}}$$

$$\boxed{f = 16Hz}.$$

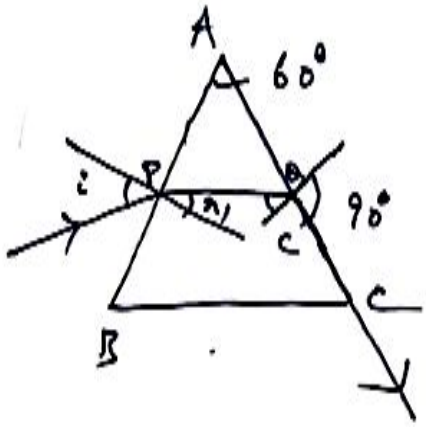
b) $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$.

$$Q = \frac{1}{40}\sqrt{\frac{5}{20\times10^{-6}}} \Rightarrow \boxed{Q = 12.5}.$$

c) Impedence at Resonant $Z = R$.

$$\boxed{Z = 40\Omega}$$

36. At what angle should a ray of light be incident on the face of an equilateral prism, so that it just suffers total internal reflection at the other face? The refractive index of the material of the prism is 1.5.



Given,

Angle of prism $(A) = 60°$.

$R.I = \mu = 1.5$.

we know that,

$$\mu = \frac{1}{\sin C}$$

$$\sin C = \frac{1}{\mu} = \frac{1}{1.5} = 0.66.$$

$$\therefore C = \sin^{-1}(0.66)$$

$$\boxed{C = 41°}.$$

We know that, $r_1 + C = A$.

$$\therefore r_1 = A - C.$$

$$= 60 - 41$$

$$\boxed{r_1 = 19°}.$$

Apply Snell's law

$$\mu_1 \sin i = \mu_2 \sin r_1.$$

$$(1)(\sin i) = (1.5)\sin 19°. \quad (\because r_1 = 19°).$$

$$\therefore \sin i = 1.5 \times 0.3255$$

$$\sin i = 0.488. \Rightarrow \boxed{i = 29°}.$$

37. A copper coin has a mass of 63.0 g. Calculate the nuclear energy that would be required to separate all the neutrons and protons form each other. The coin is entirely made of $^{63}_{29}Cu$ atoms.
Mass of $^{63}_{29}Cu$ atom = 62.92960 u
Mass of proton = 1.00727 u
Mass of neutron = 1.00866 u
Avogadro's number = 6.022×1023

37). Given,

Mass of $^{63}_{29}Cu$ atom(M) = 62.92960u.

Mass of Proton(m_p) = 1.00727u.

Mass of Neutron (m_n) = 1.00866u.

Binding Energy (B.E) = Δmc^2.

$\therefore \Delta m = (Zm_p + (A-Z)m_n) - M.$

$= (29 \times 1.00727 + 34 \times 1.00866) - M.$

$= (29.21083 + 34.29444) - 62.92960$

$\Delta m = 0.575674$.

$\therefore B.E = \Delta mc^2$.

$= 0.575674 \times 931.5$

$B.E = 535.94$ Mev

Energy required E=B.E ×N

$= 535.94 \times 6.023 \times 10^{23}$ Mev

$E = 3.227 \times 10^{26}$ Mev

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