Solution

SECTION A

1. One ampere of current is that current which, if passed in each of the two parallel current carrying conductors of infinite length (one meter apart in vacuum) causes each conductor to experience a force of 2×10^{-7} Newton per meter of length of the conductor. [1]

2. The electromagnetic radiation used for

(a) water purification is Ultra violet rays. [½]

(b) eye surgery is Laser/ Ultra violet rays. [½]

3. Given frequency of carrier wave

$$fc = 2\ MHz = 2 \times 10^3 kHz$$

Frequency of modulating signal f_m = 5 kHz

Frequency of lower side band (LSB) = $f_c - f_m$

LSB $= \left(2 \times 10^3 - 5\right)$ kHz

LSB $= (1995) kHz$ [½]

Frequency of upper side band (USB)

$= f_c + f_m$

USB $= \left(2 \times 10^3 + 5\right)$ kHz

USB $= 2005\ kHz$ [½]

4. It represents a diamagnetic substance since its permeability (0.9983) is less than 1. [1]

5. The expression for Bohr's radius in hydrogen atom is given by, $a_o = \dfrac{h^2 \varepsilon_o}{\pi m e^2}$.

[½]

Where, $h \to$ plank's constant

$\varepsilon_0 \to$ permittivity of free space

$m \to$ rest mass of electron

$e \to$ charge on electron. [½]

SECTION B

6. The current in the two bulbs is the same as they are connected in series.

Now, Power $(P =) I^2 R$ [½]

$$\therefore \frac{P_1}{P_2} = \frac{I^2 R_1}{I^2 R_2} = \frac{R_1}{R_2}$$ [½]

$$\therefore \frac{P_1}{P_2} = \frac{1}{3}$$ [1]

OR

Internal resistance of the cell is given by, $r = \left(\dfrac{l_1}{l_2} - 1\right) R$ or $r = \left(\dfrac{l_1 - l_2}{l_2}\right) R$ [1]

Given, $l_1 \to 350, l_2 \to 300$ and $R \to 9\Omega$

$$\therefore r = \left(\frac{350 - 300}{300}\right) \times 9\Omega$$

$$= \frac{50}{300} \times 9\Omega = 1.5\Omega$$ [1]

7. As $\tau = pE \sin\theta$

$$\therefore 4\sqrt{3} = pE \sin\theta$$ [½]

$$\Rightarrow pE \times \frac{\sqrt{3}}{2} = 4\sqrt{3}$$

$$\Rightarrow pE = 8$$ [½]

Potential energy of dipole,

$U = -pE\cos\theta$ [½]

$U = -pE\cos 60^o$

$U = -4J$ [½]

8. (i) Mutual induction is the phenomenon of production of induced emf in one coil due to change of current in the neighbouring coil. The coil in which the current changes is called primary coil and the coil in which emf is induced is called the secondary coil. [1]

(ii) $M = 1.5H$

$I_i = OA$

$I_f = 20A$

$\Delta I = 20A,\ \Delta t = 20s$

$e = \frac{-MdI}{dt}$

$e = -1.5 \times \frac{20}{0.5}$

$e = -60V$ [½]

So the flux linked with the other coil is given by

$\Delta\phi = e\Delta t = -60 \times 0.5$

$= -30Wb$ [½]

9. We know, that for a point charge Q

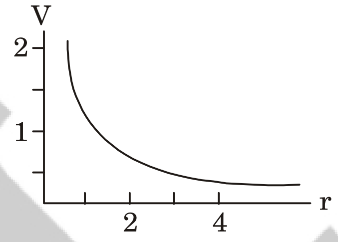
Electric potential, $V = \frac{Q}{4\pi\varepsilon_o r}$ [½]

Or $V \propto \frac{1}{r}$

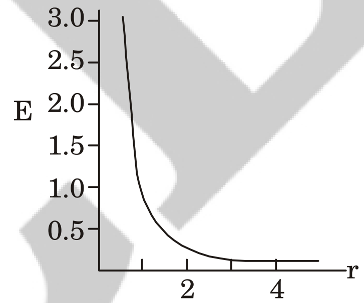
Electric field, $E = \frac{Q}{4\pi\varepsilon_o r^2}$ [½]

Or $E \propto \frac{1}{r^2}$

Thus, electric potential shows an inverse relationship while electric field shows an inverse square relationship with r. So, their corresponding plots would be,



[½]



[½]

10. We have,

Focal length of convex lens,

$f_1 = +20\,cm = +0.20\,m$

Focal length of concave lens,

$f_2 = -25\,cm = -0.25\,m$ [½]

Equivalent focal length,

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{20} + \frac{1}{-25} = \frac{1}{100}$$

$\therefore\ F = 100cm$ [½]

Power of convex lens, $P_1 = \frac{1}{f_1} = \frac{1}{0.20}$

Power of concave lens, $P_2 = \frac{1}{f_2} = \frac{1}{-0.25}$

Power of the combination lens, [½]

$$P = P_1 + P_2$$

$$= \frac{1}{0.20} + \frac{1}{-0.25}$$

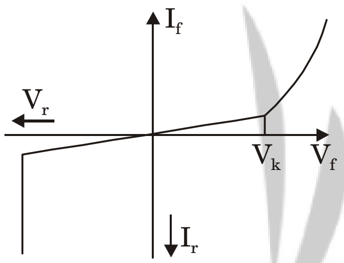
$$= \frac{100}{20} + \frac{100}{-25}$$

$$= \frac{500 - 400}{100}$$

$$= \frac{100}{100} = 1D$$

The focal length of the combination $= 1\text{ m} = 100\text{ cm}$. As the focal length is positive, the system will be converging in nature. [½]

11. [1]



(i) When p-n junction is reverse biased, the majority carriers in p and n region are repelled away from the junction. There is small current due to the minority carriers. This current attains its maximum or saturation value immediately and is independent of the applied reverse voltage. [1]

(ii) As the reverse voltage is increased to a certain value, called break down voltage, large amount of covalent bonds in p and n regions are broken. As a result of this, large electron-hole pairs are produced which diffuse through the junction and hence there is a sudden rise in the reverse current. Once break down voltage is reached, the high reverse current may damage the ordinary junction diode. Device is zener diode. [1]

SECTION C

12. **Sky wave :** Sky waves are the AM radio waves, which are received after being reflected from the ionosphere. The propagation of radio wave signals from one point to another via reflection from ionosphere is known as sky wave propagation. The sky wave propagation is an important consequence of the total internal reflection of radio waves. As we go higher in the ionosphere, there is an increase in the free electron density. Consequently, there is a decrease of refractive index. Thus, as a radio wave travels up in the ionosphere, it finds itself travelling from denser to rarer medium. It continuously bends away from its path till it suffers total internal reflection to reach back the Earth. [1]

Space waves : Space waves are the waves which are used for satellite communication and line of sight path. The waves have frequencies up to 40 MHz provides essential communication and limited the line of sight paths. [1]

(a) Sky wave mode propagation restricted to frequencies up to 40 MHz because the e.m. waves of frequencies greater than 40 MHz penetrate the ionosphere and escape. [½]

(b) In television broadcast and satellite communication, the space wave mode of propagation is used. [½]

13. $\lambda_c = \lambda_{photon} = 1.00nm = 10^{-9}m$

(a) For electron or photon, momentum

$$p = p_e = p_r = \frac{h}{\lambda}$$ [½]

$$p = \frac{6.63 \times 10^{-34}}{10^{-9}}$$

$$= 6.63 \times 10^{-25} kg\ m/s$$ [½]

(b) Energy of photon,

$$E = \frac{hc}{\lambda}$$ [½]

$$= \left(6.63 \times 10^{-34}\right) \times \frac{3 \times 10^8}{10^{-9}}$$

$$\approx 19.89 \times 10^{-17} J$$ [½]

(c) Kinetic energy of electron

$$= \frac{p^2}{2m}$$ [½]

$$= \frac{1}{2} \times \frac{\left(6.63 \times 10^{-34}\right)^2}{9.1 \times 10^{-31}} J$$

$$\approx 2.42 \times 10^{-19} J$$ [½]

14. (a) Let us consider a parallel-plate capacitor of plate area A. If separation between plates is d meters, capacitance C is given by

$$C = \frac{\varepsilon_o A}{d} F$$ [½]

We know that the magnitude of the electric field between the charged plates of the capacitor in

$$E = \frac{\sigma}{\varepsilon_o}$$ [½]

Where, σ is the surface density of either plate. Therefore, the plate charge in is $Q = \sigma A = \varepsilon_o EA$

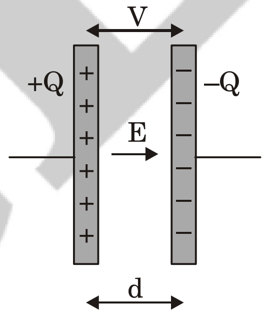
Now, the energy stored in the capacitor in

$$U = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}\frac{\left(\varepsilon_o EA\right)^2}{\varepsilon_o A/d}$$

$$U = \frac{1}{2}\varepsilon_o E^2 \left(Ad\right) J$$

The volume between the plates is Ad metre³. Therefore, the energy per unit volume is given by, [½]

$$U = \frac{U}{Ad} = \frac{1}{2}\varepsilon_o E^2 J/m^3$$ [½]



(b) Work done, $W = F.d$

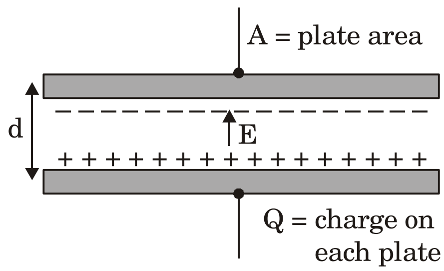
Here, F is the exerted on the charge (q) due to electric field (E) and is given by, $F = qE$

Net displacement, d = 0 [1]

Hence, W = 0

OR

(a) Derivation for the capacitance of parallel plate capacitor:



[1]

A parallel plate capacitor consists of two large plane parallel conducting plates separated by a small distance d. The two plates have charges q and -q and distance between them is d.

Plate 1 has charge density $\sigma = \frac{q}{A}$

Plate 2 has charge density $\sigma = -\frac{q}{A}$

In the inner region between the plates 1 and 2, the electric fields due to the two charged plates add up

$$E = \frac{q}{2\varepsilon_o} + \frac{q}{2\varepsilon_o} = \frac{q}{\varepsilon_o} = \frac{q}{A\varepsilon_o}$$

For this electric field, potential difference between the plates in given by,

$$V = Ed = \frac{1}{\varepsilon_o}\frac{qd}{A}$$

The capacitance C of the parallel plate capacitor is then,

$$C = \frac{Q}{V} = \frac{\varepsilon_o A}{d}$$

(b) The surface charge density for a spherical conductor of radius R_1 is given by: [½]

$$\sigma = \frac{q_1}{4\pi R_1^2}$$

Similarly, for spherical conductor R_2, the surface charge density is given by: [½]

$$\sigma_2 = \frac{q_2}{4\pi R_2^2}$$

$$\frac{\sigma_1}{\sigma_2} = \frac{q_1 R_2^2}{q_2 R_1^2} \quad ...(1)$$

As the spheres are connected so the charges will flow between the spherical conductors till their potential become equal.

$$\frac{kq_1}{R_1} = \frac{kq_2}{R_2}$$

$$\frac{q_1}{R_1} = \frac{q_2}{R_2} \quad ...(2)$$ [½]

Using (2) in (1)

We have,

$$\frac{\sigma_1}{\sigma_2} = \frac{R_1}{R_2} \cdot \frac{R_2^2}{R_1^2} \Rightarrow \frac{R_2}{R_1}$$

$$\frac{\sigma_1}{\sigma_2} = \frac{R_2}{R_1}$$ [½]

15. (i) Let the capacitance of X be C_1 and capacitance of Y be C_2

$$C_1 = \frac{\varepsilon_o A}{d}$$

$$C_2 = \frac{\varepsilon_r \varepsilon_o A}{d}$$

$$\frac{C_1}{C_2} = \frac{1}{\varepsilon_r}$$

$$\Rightarrow \quad C_2 = \varepsilon_r C_1$$

$$C_1 = C$$

$$C_2 = 4C \quad (\because \epsilon_r = 4)$$ [½]

Since two capacitance are connected in series so, equivalent capacitance will be,

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$$

$$4\mu F = \frac{C \times 4C}{C + 4C}$$

$\Rightarrow \quad C = 5\mu F$

So, $C_1 = 5\mu F$ and $C_2 = 20\mu F$ [½]

(ii) $C_{eq}V_{net} = Q_{Total}$ [½]

$4\mu F \times 15V = Q_{Total}$

$Q_{Total} = 60\mu C$

In series configuration, charge on each capacitor is equal.

Hence, $Q_1 = Q_2 = Q_{Total} = 60\mu C$

Using $Q = CV$

$$V_1 = \frac{Q_1}{C_1} = \frac{60\mu C}{5\mu F} = 12V$$

$$V_2 = \frac{Q_2}{C_2} = \frac{60\mu C}{20\mu F} = 3V$$ [½]

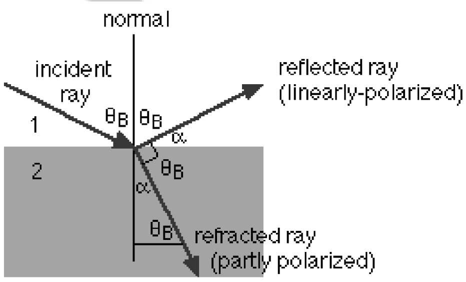
(iii) $U_1 = \frac{1}{2}\frac{Q_1^2}{C_1} = \frac{1}{2}\frac{(60\mu C)^2}{5\mu F} = 360\mu J$ [½]

$$U_2 = \frac{1}{2}\frac{Q_2^2}{C_2} = \frac{1}{2}\frac{(60\mu C)^2}{20\mu F} = 900\mu J$$

$$\Rightarrow \frac{U_1}{U_2} = \frac{4}{1}$$

$V_1 : V_2 :: 4 : 1$ [½]

16. (a) The diagram, showing polarization by reflection is as shown.



[1]

$\therefore r = \left(\frac{\pi}{2} - i_B\right)$ [½]

$\therefore \mu = \left(\frac{\sin i_B}{\sin r} = \tan i_B\right)$ [½]

Thus light gets totally polarized by reflection when it is incident at an angle i_B (Brewster's angle), where $i_B = \tan^{-1}\mu$

(b) The angle of incidence, of the ray, on striking the face AC is $i = 60°$

Also, relative refractive index of glass, with respect to the surrounding water, is [½]

$$\mu_r = \frac{3/2}{4/3} = \frac{9}{8}$$

Also, $\sin i = \sin 60^o = \frac{\sqrt{3}}{2} = 0.866$

For total internal reflection, the required critical angle, in this case, is given by

$\sin i_c = \frac{1}{\mu} = \frac{8}{9} \approx 0.89$ [½]

$\therefore i < i_c$

Hence the ray would not suffer total internal reflection on striking the face AC.

17. (a) Microwaves are suitable for radar systems that are used in aircraft navigation.

These rays are produced by special vacuum tubes, namely -klystrons, magnetrons and Gunn diodes. [1]

(b) Infrared waves are used to treat muscular strain.

These rays are produced by hot bodies and molecules. [1]

(c) X-rays are used as a diagnostic tool in medicine.

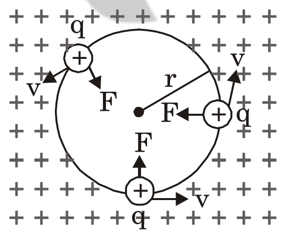
These rays are produced when high energy electrons are stopped suddenly on a metal of high atomic number. [1]

18. (i) When the number of turns in the inductor is reduced, its reactance X_L decreases. The current in the circuit increases and hence brightness of the bulb increases. [1]

(ii) When an iron rod is inserted in the inductor, the self-inductance increases. Consequently, the inductive reactance $X_L = \omega L$ increases. This decreases the current in the circuit and the bulb glows dimmer. [1]

(iii) With capacitor of reactance $X_C = X_L$, the impedance $Z = \sqrt{R^2 + (X_L - X_C)^2}$ $= R$, becomes minimum, the current in circuit becomes maximum. Hence the bulb glows with maximum brightness. [1]

19. A charge Q is projected perpendicular to the uniform magnetic field B with velocity V. The perpendicular force $F = q(v \times B)$, acts as a centripetal force perpendicular to the magnetic field. Then, the path followed by the charge is circular as shown in the figure.



[1]

The Lorentz magnetic force acts as a centripetal force, thus

$$qvB = \frac{mv^2}{r}$$

Or $r = \dfrac{mv}{qB}$ ...(1) [1]

Here, r = radius of the circular path followed by charge projected perpendicular to the uniform magnetic field.

By work energy theorem,

Loss in electrical potential energy = gain in kinetic energy

$$qV = \frac{1}{2}mv^2$$

Or $v = \sqrt{\dfrac{2qV}{m}}$

Putting these values in Eq.(1), we get

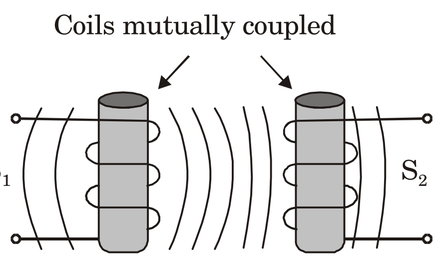
$$r = \frac{m}{qB}\sqrt{\frac{2qV}{m}}$$

$$= \sqrt{\frac{m^2}{q^2B^2} \times \frac{2qV}{m}}$$

$$\Rightarrow r = \sqrt{\frac{2Vm}{qB^2}}$$

This is the required expression of the radius in terms of V. [1]

20. Mutual inductance: The phenomenon according to which an opposing emf is produced as result of change in current or magnetic flux linked with a neighbouring coil. Mutual inductance of two long aerial solenoids: [1]



Let n_1 be the no. of turns per unit length of S_1, n_2 be the number of turns per unit length of S_2.

I_1 be current passed through S_1, ϕ_{21} be the flux linked with S_2 due to charge flowing in S_1.

$$\phi_{21} \propto S_1$$

$\phi_{21} = M_{21} I_1$ where M_{21} coefficient of mutual induction of two solenoid. When current is passed through S_1, an emf is induced in solenoid S_2. Magnetic field produced inside S_1 on passing current I_1, $B_1 = \mu_o n_1 I_1$

Magnetic flux linked with each turn of the solenoid S_2 will be equal to B_1 times the area of cross section of solenoid S_1. So, magnetic flux linked with each turn of the solenoid $S_2 = B_1 A$ Therefore, total magnetic flux linked with solenoid S_2 will be

$$\phi_{21} = B_1 A \times n_2 l = \mu_0 n_1 I_1 \times A \times n_2 l$$

$$\phi_{21} = \mu_0 n_1 n_2 A I_1 l \quad [1]$$

$$M_{21} = \mu_0 n_1 n_2 A l \quad ...(1)$$

Similarly, the mutual inductance between the two solenoids, when current is passed through S_2 and induced emf is produced in solenoid S_1 and is given by

$$M_{12} = \mu_0 n_1 n_2 A I_1 l$$

$$M_{12} = M_{21} = M(\text{say})$$

Hence coefficient of mutual induction between the two long solenoid

$$M = \mu_0 n_1 n_2 A l$$

We can write equation (i) as

$$M = \mu_0 \left(\frac{N_1}{l}\right)\left(\frac{N_2}{l}\right)\pi r_1^2 \times l$$

$$M = \frac{\mu_0 N_1 N_2 A}{l}$$

$$M = \frac{\mu_0 \mu_r N_1 N_2 A}{l} \quad [1]$$

21. Let the Alternating voltage is $V = V_o \cos \omega t$

Let $\omega L > \frac{1}{\omega C}$ then current lags by angle

Where $I_o = \dfrac{E_o}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}$

And $\tan\phi = \dfrac{\omega L - \frac{1}{\omega C}}{R}$

Therefore, Average power

$$= \frac{\int_0^T EI\,dt}{T}$$

$$= \frac{1}{T}\int_0^T (E_o \cos\omega t)(I_o \cos(\omega t - \phi))\,dt$$

$$= \frac{E_o I_o}{T}\int_0^T \left(\cos^2 \omega t \cos\phi + \cos\omega t \sin\omega t \sin\phi\right)dt$$

$$= \frac{1}{2} E_o I_o \cos\phi \quad [1]$$

$$P_{average} = E_{rms} I_{rms} \cos\phi$$

(i) If $\phi = 90 \Rightarrow P_{average} = 0$

$$\therefore \tan\phi = \frac{\omega L - \frac{1}{\omega C}}{R} = \infty$$

$$\Rightarrow R = 0 \quad [1]$$

(ii) $\Rightarrow$ *If* $\phi = 0 \Rightarrow P_{average} = Max.$

$$\tan\phi = \frac{\omega L - \frac{1}{\omega C}}{R} = 0$$

$$\Rightarrow X_L = X_C \text{ (Resonance)} \quad [1]$$

22. (i) $M = 6J/T$ [1]

$\theta = 60°$

$B = 0.44T$

$w = MB\sin\theta$

$= 6 \times 0.44 \sin 60°$

$= 6 \times 0.44 \times \dfrac{\sqrt{3}}{2}$

$= 3\sqrt{3} \times 0.44 = 2.836$

$dw \int_{\theta=60°}^{90°} mB\sin\theta d\theta = -mB[\cos 90° - \cos 60°]$

$= 6 \times 0.44 \times \left[-\dfrac{1}{2}\right]$

$= 3 \times 0.44$

$= 1.32J$

(ii) $dw = \int_{\theta=60°}^{180°} mB\sin\theta d\theta$ [1]

$= -mB[\cos 180° - \cos 60°]$

$= -6 \times 0.44\left[-1 - \dfrac{1}{2}\right]$

$= -6 \times 0.44\left[-\dfrac{3}{2}\right]$

$= 9 \times 0.44 = 39.6J$

(b) $W = m \times B$ [1]

$W = mB\sin\theta$

$= 6 \times 0.44 \times \sin 180°$

$W = 0$

SECTION D

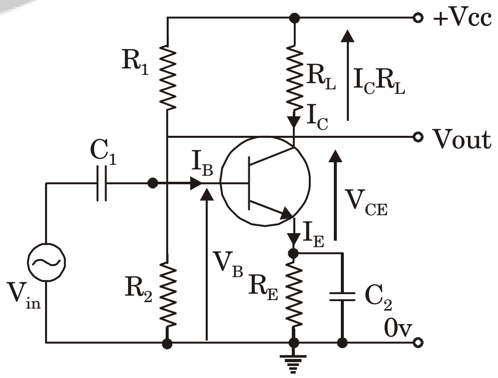
23. (a) "Oh April 1986, the world's worst nuclear accident happened at the Chernobyl. Plant near pripyat Ukraine in the soviet union. [1]

(b) An explosion and fire in the No. 4 reactorsent radioactivity into the atmosphere. [1]

(c) The value displayed by the Asha is that she is caring and having helping nature towards her mother. The value displayed by Asha's mother is that she has no idea the outburst take place in Chernobyl (Ukraine) but she has the curiosity about the incident that take place on April 26, 1986, at the Chernobyl plant near Priyat, Ukraine, in the Soviyat union. [2]

SECTION E

24. Circuit diagram of CE transistor amplifier:



[1]

Working: If a small sinusoidal voltage is applied to the input of a CE configuration, the base current and collector current will also have sinusoidal variations. Because the collector current drives the load, a large sinusoidal voltage v_o will be observed at the output. [1]

The expression for voltage gain of the transistor in CE configuration is:

$$A_v = \frac{v_o}{v_2} = \frac{-\beta_{ac} R_L}{r_i}$$ [1]

Where, β_{ac} = ac current gain

R_L = Load resistance

r = $R_B + r_i$

r_i = input resistance

R_B = Base resistance

Current gain of the transistor will decrease if the base is made thicker because current gain, $\beta = \frac{I_c}{I_b}$

If the base of an n-p-n transistor is made thicker, then more and more electrons will recombine with the p-type material of the base. This results in a decrease in collector current I_c. Furthermore, I_b also increases.

Hence, ac current gain $\beta = \frac{I_c}{I_b}$ decreases.

Finding expression for voltage gain of the amplifier:

Applying Kirchhoff's law to the output loop, [1]

$$V_{CC} = V_{CE} + I_C R_C$$

$$V_{BB} = V_{BE} + I_B R_B$$

$$v_i \neq 0$$

Then, $V_{BB} + v_i = V_{BE} + I_B R_B + \Delta I_B (R_B + r_i)$

$$\therefore \ r_i = \left(\frac{\Delta V_{BE}}{\Delta I_B}\right)_{V_{CE}}$$

$$\therefore \ v_i = \Delta I_B (R_B + r_i) = r\Delta I_B$$

$$\beta_{ac} = \frac{\Delta I_c}{\Delta I_B} = \frac{i_c}{i_b}$$

It is a current gain denoted by A_i

Change I_C due to change in I_B causes a change in V_{CE} and the voltage drop across resistance R_C, because V_{CC} is fixed.

$$\Delta V_{CC} = \Delta V_{CE} + R_C \Delta I_C = 0$$

$$\Delta V_{CE} = -R_C \Delta I_C$$

Change in V_{CC} is the o/p voltage V_o.

Voltage gain of amplifier,

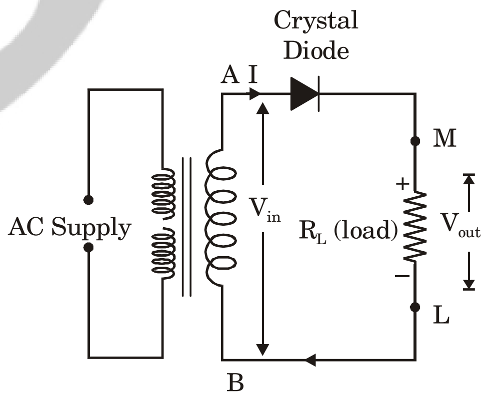
$$A_V = \frac{V_o}{V_i} = \frac{\Delta V_{CE}}{r\Delta I_B}$$ [1]

$$= -\beta_{ac} = \frac{R_C}{r}$$

Negative sign represents that o/p voltage is in opposite direction to i/p voltage.

OR

(a) Circuit diagram of a full wave rectifier using p-n junction diode is given below: [1]

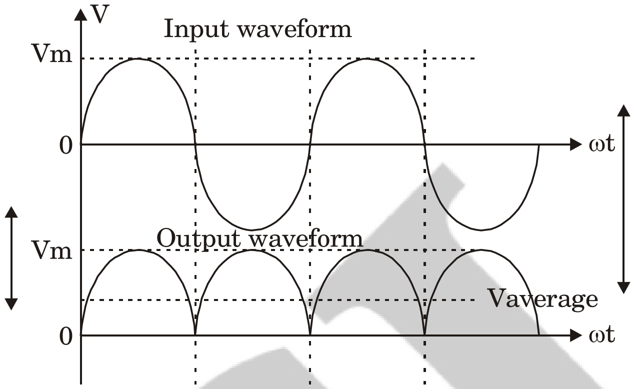


Full Wave Rectifier: [1]

When the diode rectifies the whole of the AC wave, it is called full wave rectifier.

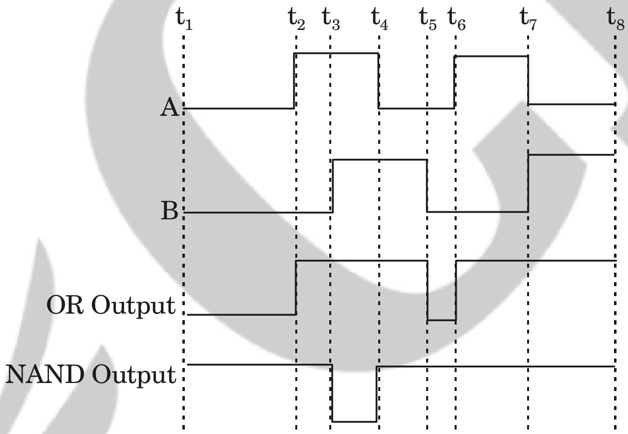
The figure shows the arrangement for using diode as full wave rectifier. The alternating input signal is fed to the primary P_1P_2 of a transformer. The output signal appears across the load resistance R_L.

During the positive half of the input signal, suppose P_1 and P_2 are negative and positive respectively. This would mean that S_1 and S_2 are positive and negative respectively. Therefore, the diode D_1 is forward biased and D_2 is reverse biased. The flow of current in the load resistance R_L is from A to B.



[1]

(b) Output waveforms (Y)



[2]

25. According to Bohr, energy is radiated in the form of a photon when the electron of an excited hydrogen atom returns from higher energy state to the lower energy state. In other words, energy is radiated in the form of a photon when electron in hydrogen atom jumps from higher energy orbit ($n = n_i$) where $n_i > n_f$. The energy of the emitted radiation or photon is given by [2]

$$h\nu = E_{n_i} - E_{n_f}$$ [1]

We know that $E_n = \dfrac{-me^4}{8h^2\varepsilon_o^2 n^2}$

$$\therefore h\nu = \frac{me^4}{8h^2\varepsilon_o^2 n_i^2} - \frac{me^4}{8h^2\varepsilon_o^2 n_f^2} \quad i.e., h\nu = \frac{me^4}{8h^2\varepsilon_o^2}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right) \text{ or } \nu = \frac{me^4}{8h^3\varepsilon_o^2}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$ [2]

Name of series

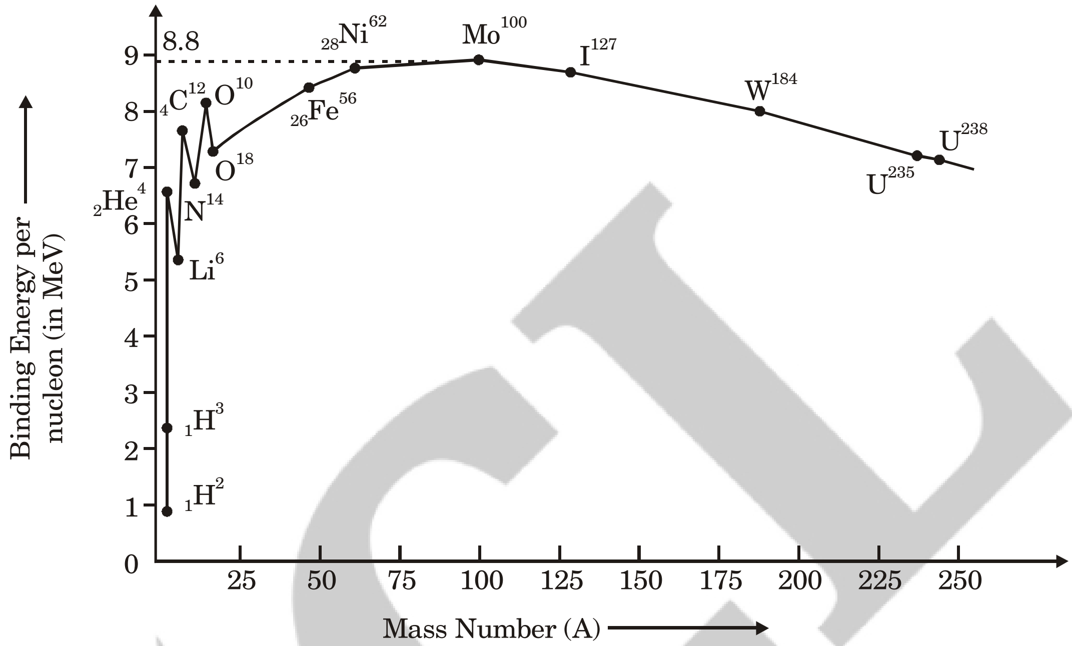
n = 4 to n = 3 (Paschen)

n = 4 to n = 2 (Balmer)

n = 4 to n = 1 (Lyman)

OR

The plot of binding energy per nucleon (BE/A) as a function of mass number is given below: [2]



Conclusions:

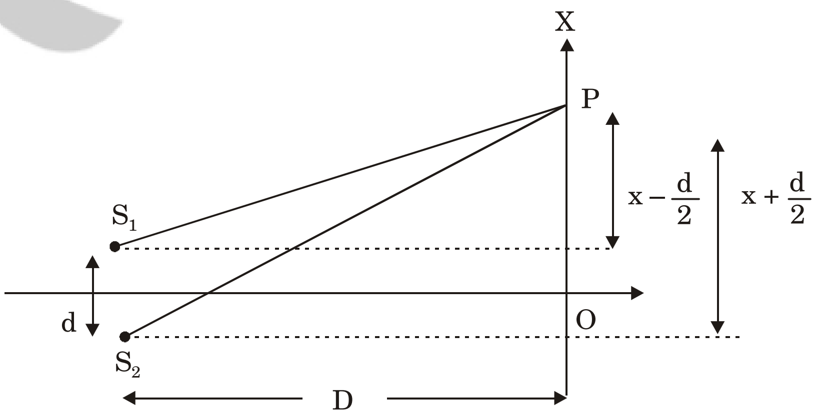
(i) The intermediate nuclei have large value of BE/A so they are more stable. [½]

(ii) BE/A has low value for both of light and heavy nuclei so they are unstable nuclei. [½

(b) In nuclear fission, unstable heavy nuclei splits into two stable intermediate nuclei and in Nuclear fusion, 2 unstable light nuclei combines to form stable intermediate nuclei so in both processes energy liberates as stability increases [1]

(c) $n \rightarrow P + \beta^0_{-1} + \bar{\nu}$ Neutrinos are difficult to detect as they go through all object by penetrating them. [1]

26. (a) The path difference between two rays coming from holes S_1 and S_2 is $(S_2P - S_1P)$. If point P corresponds to a maximum. [1]



Now $(S_2P)^2 - (S_1P)^2$

$$= \left[D^2 + \left(x + \frac{d}{2}\right)^2\right] - \left[D^2 + \left(x - \frac{d}{2}\right)^2\right]$$

$= 2xd,$

where $S_1S_2 = d$ and $OP = x$

$(S_2P + S_1P)(S_2P - S_1P) = 2xd$;

$$(S_2P - S_1P) = \frac{2xd}{(S_2P + S_1P)}$$ [1]

For maximum, $S_2P + S_1P = n\lambda$

Thus, $n\lambda = \frac{xd}{D}$

Or, $x = x_n = \frac{n\lambda D}{d}$

$n = 0, \pm 1, \pm 2, \pm 3$ ...[For maximum]

Now, for minimum,

$$S_2P - S_1P = (2n-1)\frac{\lambda}{2}$$

Thus, $(2n-1)\frac{\lambda}{2} = \frac{xd}{D}$

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

$n = \pm 1, \pm 2, \pm 3$ ....[For minima]

Thus, bright and dark bands appear on the screen, as shown in Figure. Such bands are called 'fringes'. These dark and bright fringes are equally spaced.

Expression for fringe width (β).

Let n^{th} order bright fringe is at a distance

x_n and $(n + 1)^{th}$ order bright fringe is at x_{n+1} from O, Then

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

--------[From eq. (2)] [1]

Now the fringe width is

$$\beta = x_{n+1} - x_n = \frac{\lambda D}{d}$$

Thus, the expression for fringe width is

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

(b) $\frac{I_{min}}{I_{max}} = \frac{9}{25}$;

$$\left[\frac{\left(\sqrt{I_1} - \sqrt{I_2}\right)}{\sqrt{I_1} + \sqrt{I_2}}\right]^2 = \frac{9}{25}$$

$$\frac{\left(\sqrt{I_1} - \sqrt{I_2}\right)}{\sqrt{I_1} + \sqrt{I_2}} = \frac{3}{5}$$ [1]

$$5\sqrt{I_1} - 5\sqrt{I_2} = 3\sqrt{I_1} + 3\sqrt{I_2}$$

$$2\sqrt{I_1} = 8\sqrt{I_2}$$

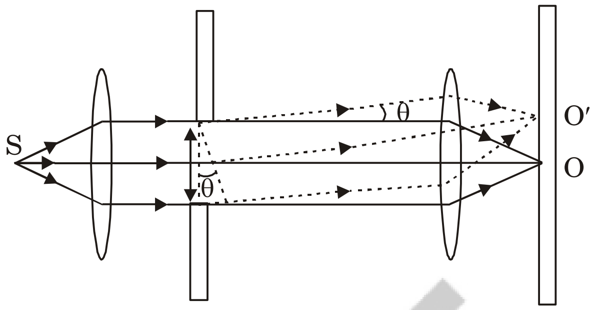
$$\sqrt{\frac{I_1}{I_2}} = \frac{4}{1};$$

$$\frac{I_1}{I_2} = \frac{16}{1}$$ [1]

Ratio of intensity

OR

(a) [1]



A point source S is placed at the focus of a converging lens. The source-lens arrangement provides a plane wavefront which is then diffracted. Another converging lens is introduced between the diffracting slit and the observation screen such that the screen is in the focal plane of the lens. Plane wavefront emerging from the slit at different angles are brought to focus on the screen using the second lens, as shown in the Fig.

Condition for minima [1]

Divide the slit into two equal halves AC and CB, each of size $\frac{a}{2}$. For every point M_1 in AC, there exists a point M_2 in CB such that $M_1M_2 = \frac{a}{2}$. The path difference between secondary waves from M_1 and M_2 reaching P is

$$M_2P - M_1P = \frac{a}{2}\sin\theta$$

Point P on the screen would be a first minimum if this path difference is λ between the secondary waves from extreme points A and B. Thus, path difference between waves from A and C or between waves from M_1 and M_2 will be $\frac{\lambda}{2}$.

Hence, $\frac{a}{2}\sin\theta = \frac{\lambda}{2}$ or $a\sin\theta = \lambda$ for P to be first minimum. P is a second minimum if Path difference, a $\sin\theta = 2\lambda$

Proceeding in the same manner, we can show that the intensity at P is zero if Path difference, a $\sin\theta = n\lambda$ (condition for minima) where n = 1, 2, 3, ……

Condition for secondary maxima: Imagine the slit to be divided into three parts AM_1, M_1, M_2 and M_2B. Let the secondary waves reaching P from the extreme points A and B be $\frac{3\lambda}{2}$. The secondary waves reaching P from the corresponding points of the parts AM_1, and M_1 M_2 will have path difference of $\frac{\lambda}{2}$ and interfere destructively. The secondary waves reaching P from points in the third part M_2B will contribute to the intensity at P. Therefore, only one-third of the slit contributes to the intensity at point P between two minima. This will be much weaker than the central maximum. [1]

This is the first secondary maximum. The condition for first secondary maximum is

Path difference, $a\sin\theta = \frac{3\lambda}{2}$.

The condition for second secondary maximum is Path difference,

$a \sin \theta = \frac{5\lambda}{2}$.

Proceeding in the same manner, we can show that the condition for a secondary maxima is Path difference,

$a\sin\theta = (2n + 1)\left(\frac{\lambda}{2}\right)$ where n = 1, 2, 3, ...

(b) For $\lambda_1 = 590 nm$ [2]

Location $= (2n+1)\frac{D\lambda_1}{2a}$

$n = 1$

$y_1 = \frac{3D\lambda_1}{2a}$

So, Difference $y_2 - y_1 = \frac{3D}{2a}(\lambda_2 - \lambda_1)$

$\frac{3\times 1.5}{2\times 2\times 10^{-6}}(6\times 10^{-9}) = \frac{27}{4}\times 10^{-3}$

Difference $= 6.75\times 10^{-3} m$

for $\lambda_1 = 596 nm$

location of 1st maxima

$y_2 = (2n+1)\frac{D\lambda_2}{2a}$

$n = 1$

$y_2 = \frac{3D\lambda_2}{2a}$