Solution

Class 12 - Physics

2020-2021 - Paper-7

Section A

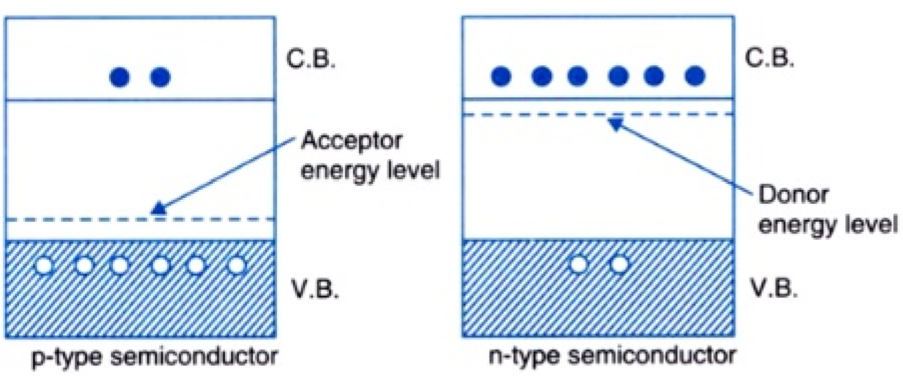
1. i. No, the stopping potential does not depend on the intensity of the incident radiation.
   ii. Yes, the stopping potential depends on the frequency of incident radiation. Above the threshold frequency, $3V_0 \propto v$
2. Clearly, $\lambda_0 = 3400\overset{\circ}{A}$ is the threshold wavelength for nickel plate. When $\lambda \leq \lambda_0$, the incident photons have energy more than or equal to the work function of Ni, so photoelectric emission occurs. When $\lambda > \lambda_0$, the energy of photons is less than the work function, so photoelectric emission does not occur.
3. $\frac{1}{\lambda}$ = R $\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$
   $\frac{1}{\lambda}$ = 1.097 $\times$ $10^7\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$
   $\frac{1}{\lambda}$ = 1.5236 $\times$ 10^6
   λ = 656.3 nm
4. Let v is velocity for an electron of H-atom in orbit, a_0 = Bohr radius or radius of orbit
   So, Number of revolutions per sec, T = $\frac{(2\pi a_o)}{v}$
   Now, current, i = -eT = -$\frac{2\pi a_0}{v}e$
   Negative sign shows direction of current is opposite to that of electron.
5. The different electrons belong to different energy levels in the conduction band. They need different energies to come out of the metal surface. For the same incident radiation, electrons knocked off from different energy levels come out with different energies.

   OR

   This signifies that the electron is bound to the nucleus. Due to electrostatic attraction between electron and nucleus, the P.E. is negative and is greater than K.E. of the electron. The total energy of the electron is negative. It cannot escape from the atom.
6. Frequency of revolution of electron, f = $\frac{v}{2\pi r}$
   where v is the velocity with which the electrons are moving, r is radius of hydrogen atom.
   Here, v = 2.2 $\times 10^6$ m/s, r = 0.53 $\times$ 10^{-10} m
   So, f = $\frac{2.2\times10^6}{2\times3.14\times0.53\times10^{-10}}$ = 6.6×10^{15} Hz
   Hence, the electron will go round the orbit 6.622×10^{15} times in one second.

   OR

   Energy band diagrams of n-type and p-type semiconductors are shown below:



7. Charge on a positron = + 1.6 $\times$ 10^{-19}C
   Charge on photon = 0
8. ${}_3^6\text{Li} + {}_0^1n \longrightarrow {}_2^4\text{He} + {}_1^3\text{H} + \text{Q}$

Initial masses	Final masses
$m\left({}_3^6\mathrm{Li}\right)$ = 6.015126amu	$m\left({}_2^4\mathrm{He}\right)$ = 4.0026044amu
$m\left({}_0^1n\right)$ = 1.0086654amu	$m\left({}_1^3\mathrm{H}\right)$ = 3.016049amu
7.0237914 amu	7.0186534 amu

Mass defect,
Δm = 7.0237914 - 7.0186534 = 0.005138 amu
Energy released,
Q = 0.005138 $\times$ 931 MeV = 4.78 MeV

9. No. Any slab, howsoever flat, will have roughness much larger than the inter-atomic crystal spacing (~2 to 3 $\overset{o}{A}$) and hence continuous contact at the atomic level will not be possible. The junction will behave as a discontinuity for the flowing charge carriers.
10. It is photodiode.
11. **(c)** Assertion is correct statement but reason is wrong statement.
    Explanation: Assertion is true but the reason is false.
    $eV_0 = h\nu - W_0$
    $V_0=\left(\frac{h}{e}\right) v-\frac{W_0}{e}$
    Slope of V_0 vs. ν graph = $\frac{h}{e}$ = constant
    $\Rightarrow$ Slope of v_0 vs. ν graph is same for different metals.
12. **(a)** Both A and R are true and R is the correct explanation of A
    Explanation: Yes because the metal will provide additional energy to the emitted photoelectron for light of higher frequency than that for lower frequency.
13. **(a)** Both A and R are true and R is the correct explanation of A
    Explanation: Both A and R are true and R is the correct explanation of A
14. **(b)** Assertion and reason both are correct statements but reason is not correct explanation for assertion.
    Explanation: Gallium arsenide phosphite has a minimum band gap of 1.8 eV required for emission of visible light.

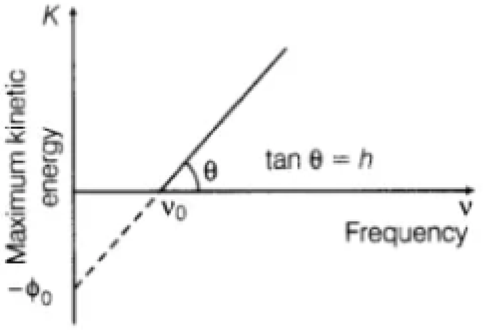
Section B

15. i. (c) 3.4 eV
    ii. (c) Angular momentum
    iii. (c) 1 : 4 : 9
    iv. (b) Decrease
    v. (a) Assumes that the angular momentum of electrons is quantized
16. i. (a) As the revolving electron loses energy continuously
    ii. (b) 2 positive charge and 4 mass unit
    iii. (d) nucleus
    iv. (b) non-centralized
    v. (c) nucleus

Section C

17. Here, $\nu=7.21 \times 10^{14} Hz$
    $v_{\max }=6.0 \times 10^5 ms^{-1}$
    $m=9 \times 10^{-31} kg$
    Applying Einsteins photoelectric equation,
    $KE_{\max }=\frac{1}{2} m v_{\max }^2=h(\nu-\nu_0)$
    $\Rightarrow \frac{1}{2} m v_{\max }^2=h(\nu-\nu_0)$
    $\Rightarrow \nu_0=\nu-\frac{m v_{\max }^2}{2 h}$
    $\Rightarrow \nu_0=7.21 \times 10^{14}-\frac{\left(9.1 \times 10^{-31}\right) \times\left(6 \times 10^5\right)^2}{2 \times\left(6.63 \times 10^{-34}\right)}$
    $=4.74 \times 10^{14} Hz$

18. Kinetic energy of photoelectrons emitted from the surface of a photosensitive material,
$KE_{max} = h\nu - \phi_o$
A graph is shown between the frequency of incident radiation (ν) and the maximum kinetic energy of the electrons emitted from the surface of a photosensitive material.



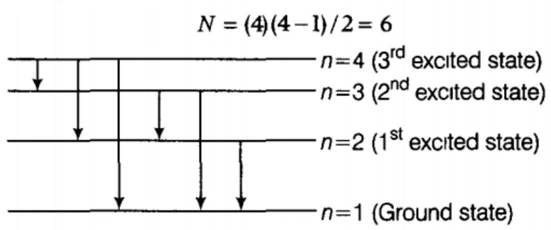
   i. So the graph between K_{max} and ν is a straight line as shown in Figure. From this graph, the Planck constant can be calculated by the slope of the current.
   Slope of K_{max}–ν graph = $\frac{\triangle K_{max}}{\triangle \nu}$ = h

   ii. Work function is the minimum energy required to eject the photo-electron from the metal surface,
   $\phi_0 = h\nu_0$, where ν_0 = Threshold frequency
   Now, Intercept on the negative K_{max} axis = ϕ_0
   Thus, Intercept on the negative K_{max} axis gives the value of work function.

19. The nucleus of a hydrogen atom is a proton (mass $1.67 \times 10^{-27} kg$) which has only about one-fourth of the mass of an alpha particle $\left(6.64 \times 10^{-27} kg\right)$. Because the alpha particle is more massive, it won't bounce back in even a head on collision with a proton. It is like a bowling ball colliding with a ping pong ball at rest. Thus, there would be no large angle scattering in this case. In Rutherford's experiment, by contrast, there was large angle scattering because a gold nucleus is more massive than an alpha particle. The analogy there is a ping pong ball hitting a bowling ball at rest.

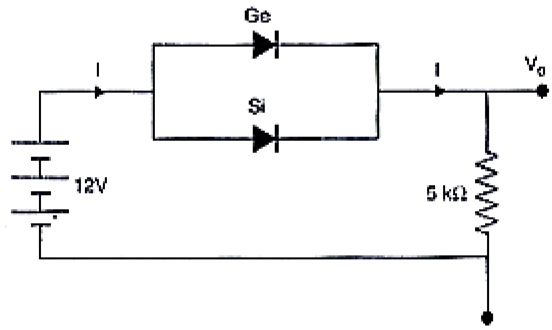
OR

The maximum number of spectral lines obtained when electron on fourth orbital jumps to ground state can be found as:
$n_2 - n_1 = 4 - 1 = 3$
The electron can make a transition from
4→3, 4→2, 4→1 = 3
3→2, 3→1 = 2
2→1 = 1
Total Number of spectral lines = 3 + 2 + 1 = 6 lines.



These lines corresponds to Paschen series.

20. **Diffusion:** It is the process of movement of majority charge carriers from their majority zone (i.e., electrons from n p and holes from p $\rightarrow$ n) due to the electric field developed at the junction. Motion gives rise to diffusion current.
Drift: Process of movement of minority charge carriers (Le., holes from n $\rightarrow$ p and electrons from p $\rightarrow$ n) due to the electric field developed at the junction.
Barrier potential: The loss of electrons from the n-region and gain of electrons by p-region causes a difference of potential across the junction, whose polarity is such as to oppose and then stop the further flow of charge carriers. This (stopping) potential is called Barrier potential.

21. 

Current, $I = \frac{12-0.3}{5\times10^3}$ = 2.34 mA

Output voltage, $V_o = RI = (5 \times 10^3) \times (2.34 \times 10^{-3})$ = 11.7 V

When the connections of Ge diode are reversed, then current will be through silicon.

In this case, $I' = \frac{12-0.7}{5\times10^3}$ = 2.26 mA

and

$V_o' = I'R = (2.26 \times 10^{-3}) \times (5 \times 10^3)$ = 11.3 V

22. **Electron volt:** It is defined as the energy gained by an electron when accelerated through a potential difference of 1 volt.

Atomic mass unit: It is defined as one-twelfth the mass of one atom of carbon-12.

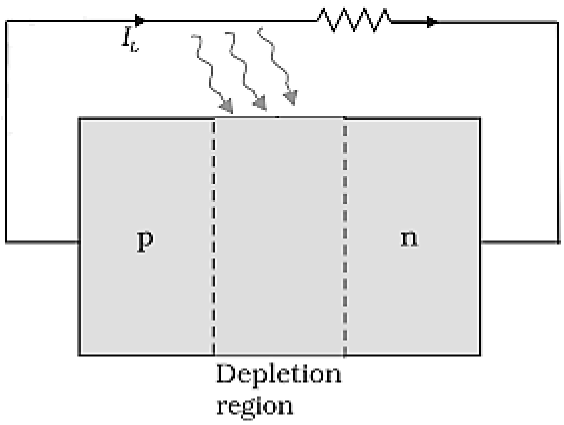
The mass of a proton is 1.67×10^{-27} kg. Therefore, the energy equivalent of this mass is,

$E = mc^2 = 1.67 \times 10^{-27} \times (3 \times 10^8)^2$

$= 1.5 \times 10^{-10}$ J

OR

A solar cell is basically a p-n junction which generates emf when solar radiation falls on the p-n junction. A typical illuminated p-n junction solar cell is shown in the Figure.



The generation of emf by a solar cell, when light falls on, it is due to the following three basic processes: generation, separation and collection—

(i) generation of e-h pairs due to light (with $h\nu > E_g$) close to the junction;

(ii) separation of electrons and holes due to electric field of the depletion region. Electrons are swept to n-side and holes to p-side;

(iii) the electrons reaching the n-side are collected by the front contact and holes reaching p-side are collected by the back contact. Thus p-side becomes positive and n-side becomes negative giving rise to photovoltage.

When an external load is connected as shown in the Fig., a photocurrent I_L flows through the load.

Solar cells are used to power electronic devices in satellites and space vehicles and also as power supply to some calculators.

23. The minimum frequency below which there is no occurrence of photoelectric effect is called the cut-off frequency or threshold frequency.

The stopping potential is defined as the potential necessary to stop any electron (or, in other words, to stop even the electron with the most kinetic energy) from reaching the other side.

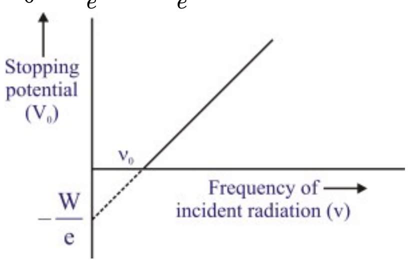
The wave theory of light is not able to explain the observed features of photoelectric current because of following reasons:

i. The greater energy incident per unit time per unit area increases with the increase of intensity which should facilitate liberation of photoelectron of greater kinetic energy which is in contradiction of observed feature of photoelectric effect.
ii. Wave theory states that energy carried by wave is independent of frequency of light wave and hence wave of high intensity and low frequency should stimulate photoelectric emission but practically, it does not happen.

24. Mass of one atom of ^{12}C
= 12amu = $12 \times 1.66 \times 10^{-27}$ kg
Energy equivalent of this mass is
E = m^2 = $12 \times 1.66 \times 1(10^{-7} \times (3 \times 10^8)^2$ J
$= \frac{12 \times 1.66 \times 9 \times 10^{-11}}{1.6 \times 10^{-13}} \mathrm{MeV}$
= 11205 MeV
25. Heavy nuclei generally have N/P ratio lower than 1. In order to be stable, the N/P ratio must tend to 1. Hence, heavy stable nucleus must contain more neutrons than protons.
i. N/P ratio decreases as in β^- decay, the atomic number Z of the nucleus goes up by 1.
ii. N/P ratio increases as in β^+ decay, Z goes down by 1.

Section D

26. i. Suppose the frequency of incident radiations of metal Q and P be ν_0 and $\nu_0{}'$ respectively.
$\therefore \nu_0 > \nu_0{}'$
$\because \nu_0 = \frac{c}{\lambda_0}$
$\therefore \frac{c}{\lambda_0} > \frac{c}{\lambda_0{}'}$
$\Rightarrow \lambda_0 < \lambda_0{}'$
Therefore, metal 'Q' has smaller wavelength.
ii. As we know,
$E = h\nu_0$
$\Rightarrow E \propto \nu_0$
Hence, metal 'P' has smaller kinetic energy.
iii. Stopping potential remains unaffected because the value of stopping potential for a given metal surface does not depend on the intensity of the incident radiation. It depends on the frequency of incident radiation.
27. i. The collision of a photon can cause emission of a photoelectron (if the frequency is above the threshold frequency). As intensity, if the frequency increases, number of photons increases. Hence, the current increases.
ii. We have, $eV_0 = h(\nu - \nu_0)$
$V_0 = \frac{h}{e}\nu - \frac{h\nu_0}{e}$



Graph of V_0 vs.ν is a straight line and slope is a constant.
iii. Maximum K.E. for different surfaces is given by = $h(\nu - \nu_0)$
Hence, kinetic energy depends on the frequency and not on the intensity of the incident radiation.
28. i. Bohr's second postulate states that the electron revolves around the nucleus in certain privileged orbit which satisfy certain quantum condition that angular momentum of an electron is an integral multiple of $h/2\pi$
i.e $L = mvr = nh/2\pi$

$2\pi r = n(h/mv)$,

Circumference of electron in n^{th} orbit = n $\times$ de-Broglie wavelength associated with electron.

ii. Number of spectral lines obtained due to transition of electron from n = 4 (3^d excited state) to n = 1 (ground state) is

$N = \frac{n(n-1)}{2}$

$N = \frac{(4)(4-1)}{2} = 6$

OR

The key idea here is that throughout the scattering process, the total mechanical energy of the system consisting of an α-particle and a gold nucleus is conserved. The system's initial mechanical energy is E_i, before the particle and nucleus interact, and it is equal to its mechanical energy E_f when the α-particle momentarily stops. The initial energy E_i is just the kinetic energy K of the incoming α-particle. The final energy E_f is just the electric potential energy U of the system. The potential energy U can be calculated from Eq. Let d be the centre-to-centre distance between the α-particle and the gold nucleus when the α-particle is at its stopping point. Then we can write the conservation of energy $E_i = E_f$ as

$K = \frac{1}{4\pi\varepsilon_0}\frac{(2e)(Ze)}{d} = \frac{2Ze^2}{4\pi\varepsilon_0 d}$

Thus the distance of closest approach d is given by:-

$d = \frac{2Ze^2}{4\pi\varepsilon_0 K}$

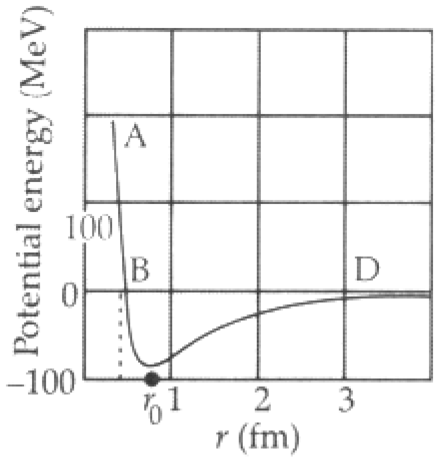
The maximum kinetic energy found in α-particles of natural origin is 7.7 MeV or 1.2×10^{-12} J. Since $1/4\pi\varepsilon_0$ = 9.0×10^9 N m^2/C^2. Therefore with e = 1.6×10^{-19} C, Z= 79 we have,

$d = \frac{(2)(9.0\times10^9 \mathrm{Nm}^2/\mathrm{C}^2)(1.6\times10^{-19}\mathrm{C})^2 79}{1.2\times10^{-12}\mathrm{J}}$

d (Au) = 3.0×10^{-14} m = 30 fm. (1 fm (i.e. fermi) = 10^{-15} m.)

The radius of gold nucleus is, therefore, less than 3.0×10^{-14} m. This is not in very good agreement with the observed result as the actual radius of gold nucleus is 6 fm. The cause of discrepancy is that the distance of closest approach is considerably larger than the sum of the radii of the gold nucleus and the α-particle. Thus, the α-particle reverses its motion without ever actually touching the gold nucleus.

29. i.



For r > r_0, the force is attractive

For r < r_0, the force is repulsive

ii. We have, In nuclear reactions , mass no .is conserved Hence ,

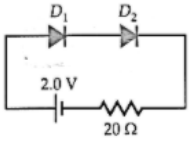
1 + 235 =a + 94 + 2 $\times$ 1

$\therefore$ a = 2 3 6 - 9 6 = 140

In nuclear reactions , charge no. is conserved .so 0 + 92 = 54 + b + 2 $\times$ 0

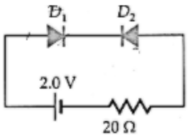
$\therefore$ b = 92 - 54 = 38

30. i. In figure (a), both the diodes D_1 and D_2 are forward biased and offer no resistance.

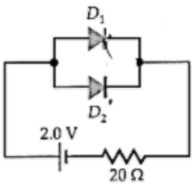


$\therefore$ Current in the circuit = $\frac{2.0\text{ V}}{20\Omega}$ = 0.1 A

ii. In Figure (b), diode D_2 is reverse biased offers infinite resistance, so the current through the series circuit = zero.

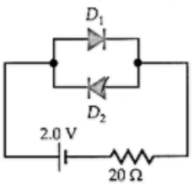


iii. In figure (c), D_1 and D_2 are forward biased and offer zero resistance.



$\therefore$ Current in the circuit = $\frac{2.0\text{ V}}{20\Omega}$ = 0.1 A

iv. In figure (d), no current flows through D_2 as it is reverse biased.



$\therefore$ Current in the remaining circuit = $\frac{2.0\text{ V}}{20\Omega}$ = 0.1 A

OR

a. Here, $v = 5.20 \times 10^6 \text{ms}^{-1}, B = 1.30 \times 10^{-4}\text{T}$, $\frac{e}{m} = 1.76 \times 10^{11}\text{Ckg}^{-1}, \theta = 90^\circ$

Force exerted by the magnetic field on the electron

$F = e|\vec{v} \times \vec{B}| = evB\sin\theta = evB$ ($\because$ sin 90^0 = 1)

since, the normal magnetic field provides the centripetal force, this gives (condition For the electron to move in a circle)

$\therefore evB = \frac{mv^2}{r}$ or $r = \frac{mv}{eB} = \frac{v}{(e/m)B} = \frac{5.20\times10^6}{1.76\times10^{11}\times1.30\times10^{-4}}$ = 0.27m = 22.7 cm

b. Energy,

E = 20 MeV $= 20 \times 1.6 \times 10^{-13}J = \frac{1}{2}mv^2 \therefore v = \left(\frac{2\times20\times1.6\times10^{-13}}{9\times10^{-31}}\right)^{1/2} = 2.67 \times 10^9\text{m/s}$

Which is greater than the velocity of light.

Therefore the formula r = mv/eB is not valid for calculating the radius of the path of 20 MeV electron beam because electron with such high energy has a velocity in the relativistic domain (ie. comparable with the velocity of light, For this, we use relativistic formula as follows.

$r = \frac{mv}{eB} = \left(\frac{m_0}{\sqrt{1-v^2/c^2}}\right)\frac{v}{eB}$

Section E

31. According to Einstein's theory of photoelectric effect,

Energy of incident photon

= Maximum K.E. of emitted photo-electron + Work function of metal

$h\nu = \frac{1}{2}mv_{\text{max}}^2 + W_0$

If V_0 is the stopping potential, then

$\frac{1}{2}mv_{\text{max}}^2 = eV_0$

$\therefore \quad h\nu = eV_0 + W_0$

or $eV_0 = h\nu - W_0$

This is the required relation between stopping potential V_0 and the frequency ν of the incident radiation.

Numerical. Here $\lambda = 0.82\overset{o}{A} = 0.82 \times 10^{-10} m$, W_0 = 0

From Einstein's photo-electric equation,

K.E. of photo-electron,

$\frac{1}{2}mv^2 = h\nu - W_0 = h\nu - 0$

or $mv^2 = 2h\nu = \frac{2hc}{\lambda}$

or $mv = \sqrt{\frac{2hcm}{\lambda}}$

$\therefore$ de-Broglie wavelength associated with the electron is

$\lambda_e = \frac{h}{mv} = \frac{h}{\sqrt{2hcm/\lambda}} = \sqrt{\frac{h\lambda}{2cm}}$

$= \sqrt{\frac{6.6 \times 10^{-34} \times 0.82 \times 10^{-10}}{2 \times 3 \times 10^8 \times 9.1 \times 10^{-31}}}$

= 0.0995 $\times$ 10^{-10} m

= 0.0995 $\overset{o}{A}$

OR

a. Energy of the incident photon,

$E = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} Js \times 3 \times 10^8 \text{ ms}^{-1}}{\lambda} = \frac{1.989 \times 10^{-25} Jm}{\lambda}$

i. For violet light, λ_1 = 390 nm (lower wavelength end), the energy of incident photon is

$E_1 = \frac{1.989 \times 10^{-25} Jm}{390 \times 10^{-9} \text{ m}} = 5.10 \times 10^{-19}$ J

$= \frac{5.10 \times 10^{-19} \text{ J}}{1.6 \times 10^{-19} \text{ J/eV}} = 3.19 \text{eV}.$

ii. For yellow-green light, λ_2 = 550 nm (average wavelength), the energy of incident photon is

$E_2 = \frac{1.989 \times 10^{-25} Jm}{550 \times 10^{-9} \text{ m}}$

= 3.62 $\times$ 10^{-19} J = 2.26 eV.

iii. For red light, λ_3 = 760 nm (higher wavelength end), the energy of incident photon is

$E_3 = \frac{1.989 \times 10^{-25} Jm}{760 \times 10^{-9} \text{ m}}$

= 2.62 $\times$ 10^{-19} J = 1.64 V.

b. A photoelectric device will operate when

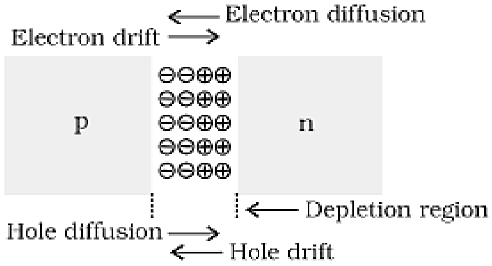
Energy E of the incident photon > Work function W_0

Thus a photoelectric device will operate with violet light (E = 3.19eV) by using photosensitive materials like Na (W_0 = 2.75 eV), K(W_0 = 2.30 eV) and Cs (W_0 = 2.14eV)

The photoelectric device will operate with yellow green light (E = 2.26 eV) by using Cs (W_0 = 2.14 eV) only.

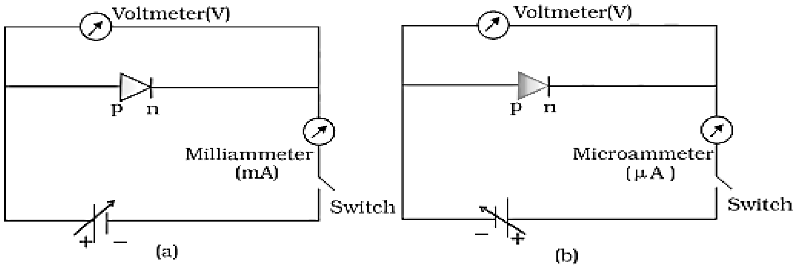
The photoelectric device will not operate with red light (E = 1.64 eV) by using any of the photosensitive materials.

32. 1. Two important processes occur during the formation of a p-n junction: diffusion and drift.

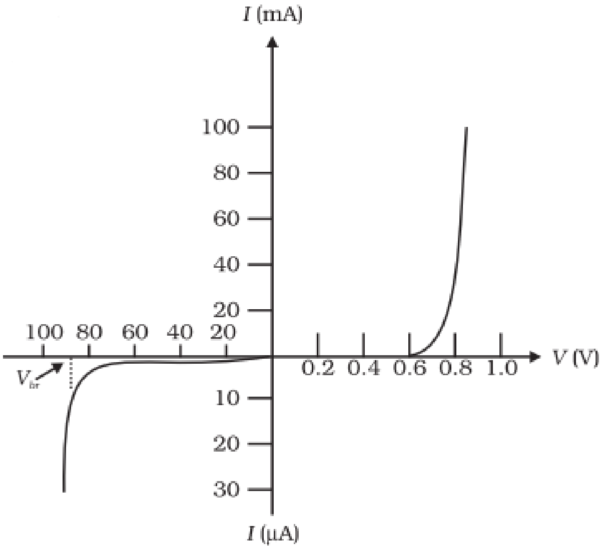


In the p-section, holes are the majority carriers; while in n-section, the majority carriers are electrons. Due to the high concentration of different types of charge carriers in the two sections, holes from p-region diffuse into n-region and electrons from n-region diffuse into p-region. In both cases, when an electron meets a hole, the two cancel the effect of each other and as a result, a thin layer at the junction becomes devoid of charge carriers. This is called **depletion layer** as shown in Fig.

2. The circuit arrangement for studying the V-I characteristics of a diode, (i.e., the variation of current as a function of applied voltage) are shown in Fig. (a) in forward bias, (b) in reverse bias.



The battery is connected to the diode through a potentiometer (or rheostat) so that the applied voltage to the diode can be changed. For different values of voltages, the value of the current is noted. A graph between V and I is obtained as in Fig. (c).



Note that in forward bias measurement, we use a milliammeter since the expected current is large while a micrometer is used in reverse bias to measure the current. We can see in Fig. (c) that in forward bias, the current first increases very slowly, almost negligible, till the voltage across the diode crosses a certain value. After the characteristic voltage, the diode current increases significantly (exponentially), even for a very small increase in the diode bias voltage. This voltage is called the threshold voltage or cut-in voltage (~0.2V for germanium diode and ~0.7 V for silicon diode).
For the diode in reverse bias, the current is very small (~μA) and almost remains constant with change in bias. It is called reverse saturation current. However, for special cases, at very high reverse bias (break down voltage), the current suddenly increases.

From the V-I characteristic of a junction diode we see that it allows current to pass only when it is forward biased. So if an alternating voltage is applied across a diode the current flows only in that part of the cycle when the diode is forward biased. This property is used to rectify alternating voltages and the circuit used for this purpose is called a rectifier.

OR

i. $mvr = \frac{nh}{2\pi}$
$\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2}$
$r = \frac{4\pi\varepsilon_0 mv^2}{e^2}$
$r = \frac{4\pi\varepsilon_0 m\left(\frac{nh}{2\pi mr}\right)^2}{e^2}$
$\Rightarrow \quad r = \frac{\varepsilon_0 n^2 h^2}{\pi m e^2}$
Potential energy, U = $-\frac{1}{4\pi\varepsilon_0}\cdot\frac{e^2}{r}$
$= -\frac{me^4}{4\varepsilon_0 n^2 h^2}$

$K.E. = \frac{1}{2}mv^2 = \frac{1}{2}m\left(\frac{nh}{2\pi mr}\right)^2$

$= \frac{n^2h^2\pi^2m^2e^4}{8\pi^2me_0^2n^4h^4}$

K.E. = $\frac{me^4}{8\varepsilon_0^2n^2h^2}$

total energy = Kinetic energy + Potential energy

$= -\frac{me^4}{8\varepsilon_0^2n^2h^2}$

ii. **Rydberg formula:** For first member of Lyman series

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

$\lambda = \frac{4}{3R} = \frac{4}{3} \times 912\overset{o}{A}$

= 1216 $\overset{o}{A}$

For first member of Balmer Series

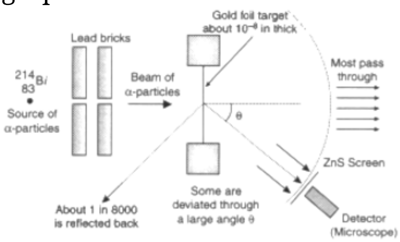
$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$

$\lambda = \frac{36}{5R}$

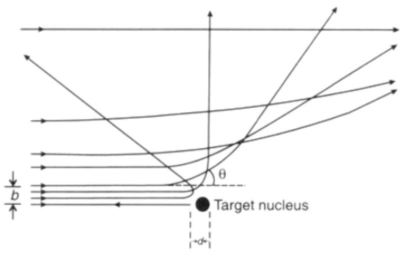
$= \frac{36}{5} \times 912\overset{o}{A}$

= 6566.4 $\overset{o}{A}$

33. i. graph is shown below :-



For most of the α-particles, the impact parameter is large, hence they suffer very small repulsion due to the nucleus and go right through the foil.



trajectory of α particle in the field

It gives an estimate of the size of the nucleus.

ii. K.E of the α-particle = potential energy possessed by the beam at a distance of closest approach.

$\frac{1}{2}mv^2 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{(2e)(Ze)}{r_0}$

$7.7 \times 1.6 \times 10^{-13} = \frac{9\times10^9\times2\times2.56\times10^{-38}\times80}{r_0}$

$r_0 = \frac{9\times10^9\times2\times2.56\times10^{-38}\times80}{7.7\times1.6\times10^{-13}}\text{m}$

= 299×10^{-16} m

= 29.9×10^{-15} m = 30×10^{-15} m.

OR

Nuclear fission is a process of splitting of a heavier nucleus into two lighter nuclei. It generally occurs in elements of high atomic mass. When these radioactive nuclides dissociate the total binding energy of product is less than that of reactants which is released energy in radioactive decay.

$\text{U}_{92}^{235} + n_0^1 \longrightarrow \text{Ba}_{56}^{141} + \text{Kr}_{36}^{92} + 3n_0^1 + Q$

In this case, the energy released per fission of U_{92}^{215} is 200.4 MeV.

Nuclear fusion is a process of a combination of two light nuclei to form heavier nuclei. It generally occurs in elements of low atomic mass. If the combined nuclear mass is less than that of iron at the peak of the binding energy curve, then the nuclear particles will be more tightly bound than they were in the lighter nuclei, and that decrease in mass comes off in the form of energy according to the Einstein relationship.

e.g. ${}_1^1H +_1^1 H \rightarrow_1^2 He + e^{+} + v + 0.42MeV$

${}_1^2H +_1^2 H \rightarrow_1^3 He + n + 3.27MeV$

${}_1^2H +_1^2 H \longrightarrow_1 H^3 +_1^1 H + 4.03Me^V$

According to the question,

${}_1^2\mathrm{H} + \mathrm{H} \longrightarrow_2^4 \mathrm{He} + n\mathrm{MeV}$

$\Delta m = (2014102 + 3.016049) - (4.002603 + 1.008665)$

= 0.018883.u

Energy released, $Q = 0.018883 \times 9315 \frac{\mathrm{MeV}}{c^2}$

= 17.589 MeV