JEE-MAIN + ADV.

TOPIC

MODERN PHYSICS

SOLUTIONS

MODERN PHYSICS

Exercise-I

1. C

$E = \frac{12400 \text{ eV}}{\lambda \text{ in } Å}$

No. of Photon $= \frac{IAt\lambda}{hc}$

No. of Photon $= \frac{Pt\lambda}{hc} = \frac{E\lambda}{hc}$

if E is constant no. of photon is $\propto \lambda$

2. B

No. of Photons $= \frac{10^{-3}}{\frac{12400}{5000} \times 1.6 \times 10^{-13}}$

$= 0.25 \times 10^{16}$

No. of e^- reaching $= \frac{0.16 \times 10^{-6}}{1.6 \times 10^{-19}} = 10^{+12}$

$\% = \frac{10^{12}}{0.25 \times 10^{16}} \times 100 = 0.04\%$

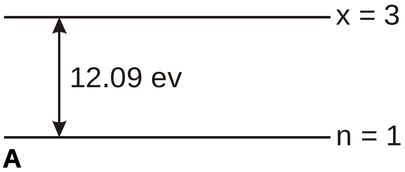
3. C

$hf = \phi + ev_S$

4. A

$hf = 1.7 + 10.4 = 12.1 \text{ eV} = $ energy

in H-atom



5. A

A Photon can interact with only a single electron.

6. C

Depends on f not on Intensity

7. D

As distance $\uparrow$ ses.

$I \downarrow$ ses.

$\therefore \; i \downarrow$

$I = \frac{P}{4\pi r^2}$

8. B

$E_{photon} = 6$ ev

Max KE = 4ev

$\phi = E_{photon} - K_{max}$

$= 6 - 4 = 2v$

then stopping Potential is 4v.

9. A

$2\phi = \phi + K_1 \quad \Rightarrow \quad K_1 = \phi = \frac{1}{2} m v_1^2$

$5\phi = \phi + K_2 \quad \Rightarrow \quad K_2 = 4\phi = \frac{1}{2} m v_2^2$

$v_1 : v_2 = 1 : 2$

10. C

If v_1, v_2, v_3 are in A.P. then

$\frac{hc}{\lambda_1} = \phi + eV_1$ ....(1)

$\frac{hc}{\lambda_2} = \phi + eV_2$ ....(2)

$\frac{hc}{\lambda_3} = \phi + eV_3$ ....(3)

After solving (1), (2) and (3) we get

$\lambda_2 = \frac{2\lambda_1 \lambda_3}{\lambda_1 + \lambda_3}$ which are in H.P.

11. B

$KE_{max} = 2ev$

$E_{photon} = 5ev$

$\phi_0 = 5ev - 2ev = 3ev$

Now no current when

$E_{photon} = 6ev$

i.e. $KE_{max} < 3ev$

$eV_{max} < 3ev$
$V_{max} < 3ev/e = 3V$
$\because \quad \phi = 3eV$

$\therefore \quad K.E._{max} = 3eV$ in Second case

12. B
no. of Photons $\propto$ I
I $\uparrow$, no. of photon e^- ejection $\uparrow$

13. A
Greater work function means greater cut off frequency.
Slope Remains same
$\phi_y > \phi_x$
Intercept of y > Intercept of x
and must be parallel to each

14. B
Diameter is same so light falling will be same so photoelectric current will be same.

15. C
They have same K.E.

$$\lambda = \frac{h}{\sqrt{2m\,K.E.}}$$

$m_p > m_e$ and $q_p = q_e$

$\lambda_p < \lambda_e$ as $\lambda \propto \frac{1}{\sqrt{m}}$

16. A

$KE = 100 + 50 = 150\,eV$

$v = 150\,volt$

$$\lambda = \sqrt{\frac{150}{V}}$$

$\lambda = 1\,\overset{0}{A}$

17. D

$$\frac{h}{\lambda} = 10^{12} h$$

18. B

$$J = mvr = \frac{nh}{2\pi}$$

$\Rightarrow \quad n = 3$

$$K.E. = -T.E. = 13.6 \times \frac{1}{9}$$

$= 1.51ev$

19. C

$$\Delta E = Rcz^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = \frac{hc}{\lambda}$$

$C \longrightarrow Shortest$

$D \longrightarrow longest$

20. C

$$I.E. = \frac{2.18 \times 10^{-18}}{n^2}$$

$$= \frac{2.18 \times 10^{-18}}{9}$$

$= 2.42 \times 10^{-19}$ J

21. A

$$\frac{\left((n+1)-3\right)\left((n+1)-3+1\right)}{2} = 10$$

(n-2) (n+1) = 20
$n^2 - 3n - 18 = 0$
n = 6

22. D

$$0.529\left[(n-1)^2 - n^2\right] = 0.529(n-1)^2$$

$\Rightarrow \quad 2n + 1 = n^2 + 1 - 2n$

$\Rightarrow \quad n = 0, 4$

23. D

$$a = \frac{v^2}{R} \propto \frac{z^2/n^2.z}{n^2} \propto \frac{z^3}{n^4} \propto \frac{1}{n^4}$$

$\therefore \quad 16:81$

24. B

$$f = \frac{\omega}{2\pi} \propto \frac{v}{r} \propto \frac{z/n}{n^2/z} \propto \frac{z^2}{n^3} \propto \frac{1}{n^3}$$

As per queestion

$$f_1 = \frac{1}{27} f_2$$

$$\frac{1}{n_1^3} \propto \frac{1}{27} \times \frac{1}{n_2^3}$$

$n = 3n_2$

25. C

$r_0 = a_0 = 0.529\,A^0$

$r_n = a_0 n^2$

26. A

$$E = 13.6\frac{z^2}{n^2} = 13.6 \times \frac{1}{2^2}$$

= 3.4 ev

27. C
n - 1 = 5
n = 6

No. of briught lines = $\frac{n(n-1)}{2}$

$$= \frac{6 \times 5}{2} = 15$$

28. C

$P = \frac{E}{C}$ $n_1 = 1, n_2 = 5$

$= \frac{\left(\frac{13.6}{1^2} - \frac{13.6}{5^2}\right)}{3\times10^8} \times 1.6\times10^{-19}$

$= \frac{13.056}{3} \times 1.6\times10^{-27}$

$mv = 6.96 \times 10^{-27}$

$v = 4.2$ m/s

29. D

$\Delta E = Rcz^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = \frac{hc}{\lambda}$

$\frac{1}{\lambda} \propto z^2$

For $z = 3$ Li^{+2}

λ will be minimum

30. C

$r \propto \frac{n^2}{z}$

$f \propto \frac{1}{n^2}$ & $T \propto n^3$

$\frac{T_1}{T_2} = \frac{n_1^3}{n_2^3} = \frac{1}{2^3}$

$\therefore$ 1 : 8

31. B

Total no. of oribits are $(n+1)$

No. of spectral lines = $\frac{n(n+1)}{2}$

It is the sum of n natural nos.

So no of different spectrum lines = $1+2+3+....+n$

n^{th} Emitted state means $(n+1)$

32. A

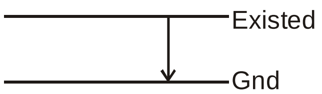
$\because$ If K.E.<13.6ev

$\Delta E = \{0, 10.2, 12.09.......13.6ev\}$

Collision must be elastic

33. A

$\because$ T.E.=P.E.+K.E.



$\Delta E \uparrow$

So both P.E. & K.E. $\downarrow$

34. B

$r = 0.529 \times \frac{n^2}{Z}$

$0.529 \times \frac{2^2}{2}$

$r = 1.06\ A^0$

35. A

E = -3.4 ev (for n = 2)

———— n = 2

angular momentum = $\frac{2h}{2\pi} = \frac{h}{\pi}$

36. C

$\because\ \Delta E = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{\Delta E}$

$\lambda_p < \lambda_q$

$\Delta E_P < \Delta E_Q$

$\because\ \Delta E_{K\alpha} < \Delta E_{K\beta}$

So $Q \longrightarrow K_\alpha$

$P \longrightarrow K_\beta$

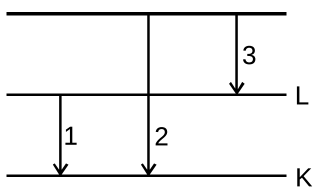
37. C

0.1 to 10 $\overset{0}{A}$ (x-ray range)

38. D

When freqency is increased energy increases i.e. penetrating power increases

39. C



$E_1 + E_3 = E_2$

$h\nu_{k\alpha} + h\nu_{L\alpha} = h\nu_{k\beta}$

$\nu_{k\beta} = \nu_{k\alpha} + \nu_{L\alpha}$

40. B

When ever the energy of photon is doubled then work function increases must more than by 2 times.

41. D

42. B

43. A

The energy of each photon should be indiviually greater than the work function for PEE to occur.

44. A

Electron is lighter $\lambda = \frac{h}{mv}$

45. D

$\lambda = \frac{h}{mv}$ momentum is vector quantity therefore is magnitude is asked then we can say 1 is correct

46. D

Exercise - I

1. D

$\frac{hc}{\lambda} = \phi + K$

$\Rightarrow \frac{4hc}{3\lambda} = \frac{4\phi}{3} + \frac{4K}{3}$ ....(1)

$\frac{4hc}{3\lambda} = \phi + K'$ $\Rightarrow \frac{4hc}{3\lambda} = \phi + K'$ ......(2)

equation (2) - equation (1)

$K' - \frac{4}{3}K - \frac{4\phi}{3} + \phi = 0$

$K' = \frac{4}{3}K + \frac{\phi}{3} > \frac{4K}{3}$

2. C

no. of Photons $= \frac{\text{Total Energy}}{\text{Energy of one Photon}}$

so no effect on current

$KE_{max} = h\nu - \phi$

$2(KE)_{max} = 2h\nu - 2\phi$ ....(i)

$(KE)_{max} = 2h\nu - \phi$ ....(ii)

$(ii) - (i)$

$(K.E.)_{max} = \phi > 0$

3. D

ϕ = 4ev; $K.E._{max} = E - \phi$; eV_0 = (13.6-4) eV

V_0 = 9.6 V

for zero photo current

V_{anode} must be $> V_s \Rightarrow V_{anode}$ = 10 V

4. C

$\frac{hc}{\lambda_1} = \phi + K_1$ $\Rightarrow \frac{2hc}{\lambda_1} = 2\phi + 2K_1$ ....(1)

$\frac{2hc}{\lambda_1} = \phi + K_2$ $\Rightarrow \frac{2hc}{\lambda_1} = \phi + K_2$ ....(2)

Now eq. (1) – eq. (2)

$\phi + 2K_1 - K_2 = 0$

$K_2 = \phi + 2K_1$

$\frac{K_2}{2} = \frac{\phi}{2} + K_1$ $\Rightarrow \therefore K_1 < \frac{K_2}{2}$

5. C

$V - 0 = \frac{eV_1}{f_1 - f_0}(f - f_0)$; $\phi = \frac{eV_1 f_0}{f_0 - f_1}$ or $\phi = f_0 h$

$KE_{max} = E - \phi = hf_1 - hf_0$

6. B

Energy of a Photon $= \frac{1240}{200}$ = 6.2ev

KE_{max} 6.2 - 4.5 = 1.7eV

Collector plate will attract it & the potential 2V increase KE by 2eV

So max KE = 3.7 eV

7. B

$I = \frac{nhc}{\lambda At} = \frac{nh\nu}{At}$

I reamains same but ν changes and increases n decreases

$\Rightarrow$ Photo current decreases

8. C

9. B

$\lambda = \frac{12.27}{\sqrt{V}}$ $Y = \frac{\lambda D}{d}$

$V\uparrow \lambda\downarrow$

10. A

$\frac{K3q^2}{r^2} = \frac{mv^2}{r}$

and $mvr = \frac{nh}{2\pi}$

for $n = 1$ $r_{min} = \frac{3q^2}{2\varepsilon_0 h}$

11. A

$\lambda_n = \frac{h}{mv_n}$ and $J = \frac{nh}{2\pi}$

$J \propto n$

$\lambda_n = \frac{h}{m \times 2.18 \times 10^6} \times \frac{n}{z}$

$\lambda_n \propto n$ & $J_n \propto \lambda_n$

12. A

$$E_n = \frac{-mz^2e^4}{BE_0^2h^2n^2} \quad , \qquad V = \frac{Ze^2}{2E_0nh}$$

$$r = \frac{E_0h^2}{\pi mZe^2} \times \frac{n^2}{Z}$$

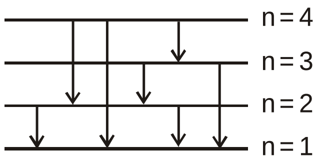
$$f = \frac{\omega}{2\pi} = \frac{r}{2\pi R} = \frac{2En}{nh}$$

13. D

$$\frac{E_{4n} - E_{2n}}{E_{2n} - E_n} = \frac{-13.6\left(\frac{z^2}{(4n)^2} - \frac{z^2}{(2n)^2}\right)}{-13.6\left(\frac{z^2}{(2n)^2} - \frac{z^2}{(n)^2}\right)}$$

14. C

$Six\ difference \rightarrow n = 4$



15. A

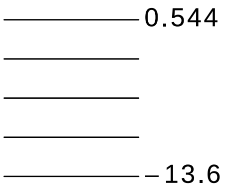
$$r \propto \frac{1}{m}$$

$$r = 0.529 \times \frac{n^2}{2} \times \frac{1}{207} = 2.56 \times 10^{-3}\ A^0$$

16. A

$10 \rightarrow$ different wavelength

Means n = 5



$$\frac{n(n-1)}{2} = 10$$

n = 5

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

$$\frac{1}{\lambda} = R\left(1 - \frac{1}{25}\right)$$

$$\lambda = \frac{25}{24} \times 932 A^\circ = 95\,nm$$

17. C

for largest warelength of Balmer series
n=3 to n=2
So Electron will jump from ground state to n=3
Energy Required = 13.6 - 1.51
= 12.1ev

18. C

$$f \propto \frac{\omega}{2\pi}$$

$$\propto \frac{v}{r} \propto \frac{1/n}{n^2} \propto \frac{1}{n^3}$$

$$\log\frac{1}{n^3} = \log\left(V_n/V_1\right) = -3\log x$$

19. C

$$\because\ P.E. = \frac{T.E.}{2}$$

$$\therefore\ P.E. = \frac{-13.6}{2} = -6.8\,eV$$

20. B

$$f \propto \frac{1}{n^3}$$

$r \propto n^2$

$L \propto n$

$$frl = \frac{1}{n^3} \times n^2 \times n$$

= 1 Constant

21. C

$$= \frac{12420}{0.021 \times 10}$$

= 59142 eV
= 0.059 MeV
= 59 kV

22. C

$$\frac{1}{\lambda} = R(57)^2\left(1 - \frac{1}{4}\right) \qquad ....(1)$$

$$\frac{1}{\lambda_2} = R(29)^2\left(1 - \frac{1}{4}\right) \qquad ....(2)$$

From (1) and (2)

$\lambda_2 = 4\lambda$

23. A,C

$$\phi + ev_0 = hv \qquad v_0 = \frac{hv - \phi}{e}$$

i.e. v_0 depends on frequency of incident light and work function (emitter property)

24. B,C

Photocurrent depends no. of photons following on collector-plate only.

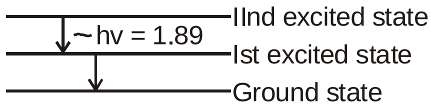
25. D

Electric field may increase or decrease the speed of electron

As $P = \frac{h}{\lambda} \Rightarrow mv = \frac{h}{\lambda}$

magnetic field will on change the speed of the particle. so $\lambda_1 > \lambda_2$ or $\lambda_1 < \lambda_2$

26. B



$Z = \frac{1.89}{10.2} = 0.185 = \frac{5}{27}$

$\frac{hc}{\lambda_1} = 1.89 \qquad \frac{hc}{\lambda_2} = 10.2$

Now $\frac{\lambda_1}{\lambda_2} = \frac{10.2}{1.89} = 5.39$

$\lambda = \frac{h}{p} \qquad P = \frac{h}{\lambda} \Rightarrow \frac{P_2}{P_2} = \frac{\lambda_2}{\lambda_1}$

$\frac{P_1}{P_2} = \frac{1.89}{10.2} = \frac{5}{27}$

27. B

$T.E. = -13.6\frac{Z^2}{n^2} \qquad -3.4 = -13.6\frac{1}{n^2}$

$n^2 = \frac{13.6}{3.4} = 4 \qquad n = 2$

$|K.E.| = |T.E.| = 3.4 \qquad P^2 = 2m \times 3.4(ev)$

$= 2 \times 9.1 \times 10^{-31} \times 3.4 \times 1.6 \times 10^{-13}$

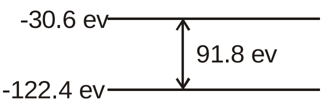
$P = 10^{-24}$

$\lambda = \frac{h}{p} = \frac{6.67 \times 10^{-34}}{10^{-24}} \qquad \lambda = 6.6 \times 10^{-10}\, m$

28. A,C,D

$122.4 = \frac{13.6 \times z^2}{1} \qquad z^2 = 9 \qquad z = 3$

Its energy level are



If e$^-$ have K.E. energy = 125 ev

then energy of average electron = 125 - 122.4 = 2.6ev

29. A,D

$\frac{T_1}{T_2} = \frac{n_1^3}{n_2^3} \qquad n_1 = 2n_2$

check options

30. A,C,D

If same energy released in y-direction then same of the incident wavelength is missing in A.

Ratio M.W. Infrared Visible Regions.

U.V. X-Ray $\xrightarrow{\hspace{2cm}}$ $\lambda \downarrow f \uparrow$

B will contain same visible and infrared light.

31. A

In ultra violet region lyman series is present

32. B

$\underline{\hspace{2cm}} 25.69 = T.E.$

Total Energy $\underline{\hspace{2cm}} 23.8 = T.E.$

increase as n increases $\underline{\hspace{2cm}} 13.6 = T.E.$

Differente B / w two shell is constant

33. A

$r \propto \frac{1}{m}$

34. A,B

$A_n = \pi r_n^2 = 0.529 \times n^4 \qquad A_1 = \pi r_1^2 = 0.529 \times 1$

$\frac{A_n}{A_1} = n^4 \qquad In\frac{A_n}{A_1} = 4\ln n$

Straight line passing though origin with slope 4.

35. A,C,D

$K = 2.55 \qquad n = 4(0.85) \qquad 10\ n = 2(3.4)$ *so* min

$\frac{K}{2} = 13.6 - 0.85 \qquad = 12.75 \qquad \boxed{K = 25.5ev}$

36. A,C

If $K < 20.4ev$

$\Delta E = \{0, 10.2ev, 12.09ev\}$

$\Delta E = \{0,\ 7ev,\}$

$loss = 0$

so elastic collision

if (K.E.) > 20.4ev

then if loss = 0 then elastic

& otherwise inelastic collision

37. B

$E = \frac{12400}{0.663} = 18700\,eV \qquad Potential = 18.7\,KV$

$Kv = \frac{1227}{\sqrt{v}} = 0.01\overset{0}{A}$

38. A,D

Minimum wavelength detreases.

$\therefore$ Intensity Increases.

39. A,B

$\lambda_{min} = \frac{12400}{20000} \qquad \lambda_{min} = 0.62\overset{0}{A} \qquad \lambda_{min} = 62pm$

12 & 45 pm will be absent

40. A,B,C

Exercise-III Level-I

1. $1m^2 \times C$ *have energy in* $1\sec = 200$

$1mm^2 \times C$ *have energy in* $1\sec = \frac{200}{C} \times 10^{-6}$

$no.of\ photons = \frac{Energy}{hc/\lambda}$

$= \frac{200\times10^{-6}\times2640\times10^{-10}}{3\times10^{8}\times1240\times1.6\times10^{-19}}$

= 885

2.

$4.25 = \phi_A + T_a$ ....(1)

$4.7 = \phi_B + T_b$ ....(2)

$T_b = (T_a - 1.5)$..............(3)

$\lambda_a = \frac{h}{\sqrt{2M_eT_a}}$..............(4)

$\lambda_b = \frac{h}{\sqrt{2M_eT_b}}$..............(5)

By $4 \div 5$

given $\lambda_b = 2\lambda_a$

$\frac{\sqrt{a}}{\sqrt{b}} = 4 \Rightarrow \sqrt{a} = 4\sqrt{b}$

by (3)

$\sqrt{b} = \frac{1}{2}ev$ & $\sqrt{a} = 4\sqrt{b}$

by (1) & (2)

$\phi_A = 2.25ev$

$\phi_A = 4.2ev$

3.

$\because i = nef$

$sn = \frac{I}{4\pi r^2} \times \frac{1}{hf}$

$\Rightarrow \frac{i_1}{i_2} = \frac{r_2^2}{r_1^2}$

$\Rightarrow \frac{18mA}{i_2} = \frac{(0.6)^2}{(0.6)^2}$

$i_2 = 2mA$

$\because$ I same so V_0 will remain same.

4. When
$h\nu = (3+1)ev = 4ev$

5. $no\ of\ photon = \frac{663\times10^{-3}\times540\times10^{-16}}{1240\times1.6\times10^{-19}}$

$no\ of\ e^-emitted = \frac{1.8\times10^{19}}{5\times10^{9}}\times10^{-1}$

$i = 0.36 \times 10^9 \times 1.6 \times 10^{-19}$

$\Rightarrow i = 5.76\times10^{-11}\ A$

6. **I case**

$E_1 = \frac{12400}{3300} = 3.76ev$

II case

$E_2 = \frac{12400}{2200} = 5.64ev$

$3.75 = \phi + V_0$

$5.64 = \phi + 2V_0$

$V_0 = 1.88\ ev$

7.

$(i)\ avg\ no\ of\ photons = \frac{10}{4\pi(0.1)^2} \times \frac{\pi(0.05)^2\times10^{-18}}{}$

$\times \frac{99\times10^{-12}}{1240\times1.6\times10^{-19}}$

8.

$\because h(f_2 - f_1) = e(V_{o2} - V_{o1})$

$\Rightarrow h = \frac{e(V_{o2} - V_{o1})}{f_2 - f_1}$

$\Rightarrow h = 6.53\times10^{-34}$

9.

$\frac{h}{mv} = \frac{h}{\sqrt{2meE\frac{1}{2}\frac{eE}{m}t^2}}$

$= \frac{h}{eEt}$

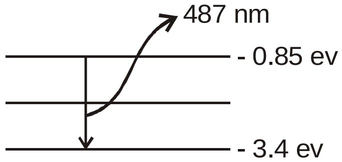
10.

$P = \frac{h}{\lambda} = \frac{6.63\times10^{-34}}{10^{-14}}$

$KE = \frac{p^2}{2m}$

$\boxed{KE = 8.6MeV}$

11.



12.

$n = 6 \quad E_5 = \frac{-13.6}{36} = -0.38ev$

$n = 1 \quad E_1 = -13.6$

$\Delta E = 13.2ev$

$V = \frac{13.2}{mc}$

13.

For Balmer series

$n \to 5 \to 2$

$\frac{1}{\lambda_1} = Rz^2\left(\frac{1}{2^2} - \frac{1}{5^2}\right)$

14.

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

$\lambda = \frac{hc}{\Delta E} \qquad here\ \Delta E = 54.4ev$

$\Rightarrow \quad \lambda = \frac{12400}{54.4}$

$\Rightarrow \quad \lambda = 22.8\,nm$

15.

$\frac{1}{\lambda_2} = Rz^2\left(\frac{1}{1^2} - \frac{1}{2^2}\right)$ ....(*i*)

$\frac{1}{\lambda_1} = Rz^2\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$ ....(*ii*)

$\frac{1}{\lambda_3} = Rz^2\left(\frac{1}{1^2} - \frac{1}{3^2}\right)$ ....(*iii*)

from (*i*),(*ii*) & (*iii*)

$\frac{1}{\lambda_3} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$

16.

$\because \quad E \propto m$

$\frac{1}{\lambda} = Rz^2\left(\frac{1}{n_c^2} - \frac{1}{n_{13}^2}\right)$

$\frac{1}{\lambda} = 2R \times 5\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$

$\lambda = \frac{18}{5R}$

17.

$M = \frac{evr}{2}$

$v = 2\pi rf$

$\therefore \quad M = \frac{1.6\times10^{-19}\times2\times3.14\times10^{16}\times(0.5)^2\times10^{-20}}{2}$

$M = 1.257\times10^{-23}\ Am^2$

18.

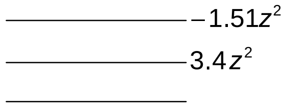
$h\nu + h\nu = 2mc^2$

$\frac{2hc}{\lambda} = 2mc^2$

$\frac{2\times1.2\times10^{-12}\ Mev}{\lambda} = 2\times\frac{0.5}{c^2}\times c^2$

$\therefore \quad \lambda = 2.48\times10^{-12}\ m$

19.



$(3.4 - 1.51)z^2 = 47.2ev$

$\Rightarrow \quad z = 5$

20.

(*a*) $\quad (3.4 - 1.51)z^2 = 47.2ev$

$\Rightarrow \quad z = 5$

(*b*) $\quad \Delta E = z^2(1.51 - 0.85)$

$\Delta E = 16.5ev$

(*c*) $\quad \lambda = \frac{12400}{13.6\times5^2} = 36.4\,A^0$

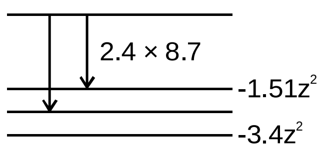
(*d*) $\quad K.E. = +13.6\times z^2$

$P.E. = -13.6\times5^2\times2$

$A.M. = h/2\pi$

(*e*) $\quad r = 0.529\times\frac{1^2}{5}$

21.



$(3.4-1.51)\ z^2 = 17.0$

$z = 3$

$n = 7$

22.

Energy of the electron in ground state $= -13.6z^2$ ev

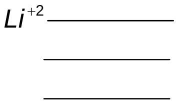
$$\frac{1}{\lambda} = z^2 R\left(\frac{1}{2^2} - \frac{1}{5^2}\right) = \frac{10^9}{108.5}$$

$$or \qquad Rz^2\left(\frac{21}{100}\right) = \frac{10^9}{108.5}$$

$$\Rightarrow \qquad z^2 = \frac{10^{11}}{108.5 \times 21R}$$

$$E_1^2 = -13.6z^2 = -54.4ev$$

23.



$$-13.6\times\frac{3^2}{3^2} \qquad -13.6\times\frac{3^2}{n^2}$$

$$n = 3 \quad r \propto \frac{n^2}{z}$$

24.

$$\frac{1}{1000} = Rz^2\left[\frac{1}{3^2} - \frac{1}{n^2}\right]$$

Now from this value of n we get the number of lives

25.

$$\lambda_m T \rightarrow \text{constant}$$

$$(9000)\ T_1 = \lambda_2 T_2$$

$$U = \sigma e A T^4$$

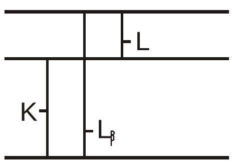
$$U_2 = 16U_1$$

26. $r \propto \frac{n^2}{2}$

$$E_{K\beta} = E_{K\alpha} + E_{L\alpha}$$

$$hf_{K\beta} = hf_{K\alpha} + hf_{L\alpha}$$

$$f_{K\beta} = f_{K\alpha} + f_{L\alpha}$$



27. $E = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2}$

$$\lambda_2 - \lambda_1 = 130 \times 10^{-12}\ m$$

28. $E_{K\alpha} = \frac{12420}{2} = 6210ev$

$$E_{K\beta} = \frac{12420}{2} = 12420ev$$

for L_α transition

(from n=3 to n=2)

Energy diff. = 6210 ev.

29.

$$E = \frac{1240}{400} = 8.1ev$$

$$W.f. = 1.9ev$$

$$(KE)_m = 1.2\ ev$$

$$\Sigma = -13.6\frac{z^2}{n^2}$$

$$= -13.6\times\frac{4}{25} = -2.176ev$$

$$Photon\ Energy = 2.17 + 1.2$$

$$= 3.37ev$$

30.

Energy diff. b/w (1) & (2) is

$$= \frac{12400}{21.3\times 10^{-2}} \quad (in\ \overset{0}{A})$$

$$= 58.2Kev$$

Total energy Required

$$= 58.2 + 11.3$$

$$= 69.5\ Kev$$

31.

$$KE = |TE| = 3.4ev$$

$$3.4ev = \frac{p^2}{2m}$$

$$p = 10^{-24}$$

$$\lambda = h/p = \frac{6.67\times 10^{-34}}{10^{-24}}$$

$$\boxed{\lambda = 6.6\times 10^{-10}\ m}$$

32.

$$\lambda_{min} = \frac{12400}{20\times 10^3}$$

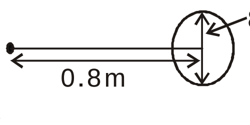
$$\lambda_{min} = 0.62\overset{0}{A}$$

—==================—

Exercise-III Level-II

1. P = 3.2×10^{-3}

(a)



$$\frac{3.2 \times 10^{-3}}{5 \times 1.6 \times 10^{-19}} = 0.4 \times 10$$

No. of Photons falling =

$$\frac{3.2 \times 10^{-3}}{4\pi \times (0.8)^2} \times \frac{\pi(8 \times 10^{-3})^2}{5 \times 1.6 \times 10^{-19}} = 10^{11}$$

No. of Photo electron = $\frac{10^{11}}{10^6} = 10^5 \sec^{-1}$

(b) Photo electrons :-
2 eV = K.E. =

$$5 = \frac{12400}{\lambda_{photon}} \Rightarrow \lambda ph\theta = 2480 \text{ Å}$$

$$\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2m K.E.}}$$

$\therefore$ Ratio = 286 : 18

$$= \frac{0.8692 \times 10^{-9}}{8.692 \times 10^{-9}}$$

(C)
Due to ↑ in Potential of the sphere Potential becomes $2V_0$. Energy required is 2 eV extra the n ∴ e^- stops.

(D)

$$\frac{kq}{r} = 2V$$

$$\frac{9 \times 10^9 \times q}{8 \times 10^{-3}} = Z$$

$$\therefore \text{no. of } e^- \text{ ejected} = \frac{16 \times 10^{-12}}{9 \times 1.6 \times 10^{-19}} = \frac{10^8}{9}$$

$$\therefore e^- \text{ coming out per second} = 10^5$$

$$t = \frac{10^8}{9 \times 10^5} = 111.11 \sec.$$

2.
First line of lyman series means $n_2 = 2$, $n_1 = 1$

$$\frac{1}{\lambda} = Rz^2\left[\frac{1}{1^2} - \frac{1}{2^2}\right]$$

$$\Rightarrow \frac{1}{\lambda} = 1.097 \times 10^7 \times 2^2\left[1 - \frac{1}{4}\right]$$

$$\frac{1}{\lambda} = 3 \times 1.097 \times 10^7 = 3.291 \times 10^7 \Rightarrow \lambda$$
= 303.85 Å

$$\text{Energy} = \frac{12400}{\lambda(\text{in Å})} eV = 40.80 eV$$

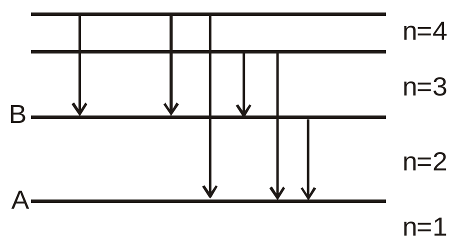
Now this energy is used to leberate photo electron from H atom then

$$\frac{1}{2}mv^2 = (40.80 - 13.6) = 27.20 eV$$

$$\Rightarrow v = \sqrt{\frac{2 \times 27.20 \times 1.6 \times 10^{-19}}{9.1 \times 10^{-31}}}$$

$\Rightarrow$ v = 3.1×10^6 m/sec

3.



(i) From $\frac{n(n-1)}{2} = 6$ gives the final state is n = 4. The energy level of H atom are given by

$$E_n = \frac{-13.6}{n^2} eV$$

If n_B is the principla quantum no. of the initially exicted state B then

$$E_4 - E_{n_B} = \frac{-13.6}{4^2} - \left(\frac{-13.6}{n_B^2}\right) = 13.6\left(\frac{1}{n_B^2} - \frac{1}{16}\right)$$

Now $E_4 - E_{n_B} = 2.7 eV$

Thus $2.7 = 13.6\left[\frac{1}{n_B^2} - \frac{1}{10}\right]$

Which gives $n_B \simeq 2$. The different transitions are as shown in figure.

(ii) The ionisation energy is numerically equally to the ground state energy E_1 of level A.

Now $E_4 = \frac{E_1}{16}$, $E_2 = \frac{E_1}{4}$

and $E_4 - E_2 = \frac{E_1}{16} - \frac{E_1}{4}$

or 2.7 eV = $\frac{-3}{16}E_1$ or E_1 = – 14.4 eV

Thus the ionisation energy of the given atom is 14.4 eV = 23.04×10^{-19} J

(iii) Maximum energy of the emitted photon for the e^- transition n = 4 to n = 1
$E_4 - E_1$

$= \frac{E_1}{16} - E_1 = \frac{-15}{16}E_1 = -\frac{15}{16}\times(-14.4) = 13.5\,eV$

Thus the maximum energy of the emitted phton is 13.5 eV

Minimum energy of the emitted photon correspond to the transition n = 4 to n = 3 i.e.,

$E_4 - E_3 = \frac{E_1}{16} - \frac{E_1}{9} = -\frac{7}{144}E_1$

$= \frac{-7}{144}\times(-14.4) = 0.7\,eV$

4. $\frac{1}{\lambda} = Rz^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$\Rightarrow \frac{1}{\lambda} = 1.097\times10^7\times z^2\left[\frac{1}{2} - \frac{1}{3}\right]$

$68 = \frac{12400}{\lambda} \Rightarrow \lambda = \frac{12400}{68} = 182.35\,Å$

$\Rightarrow \frac{10^{10}}{182.35} = 1.097\times10^7 z^2\left[\frac{1}{4} - \frac{1}{9}\right]$

$\frac{10^3\times36}{200\times5} = z^2 \Rightarrow \quad z^2 = 36 \Rightarrow z = 6$

$v = 2.18\times10^6\times\frac{z}{n} = 13.08\times10^6\,m/s$

K.E. $= \frac{1}{2}mv^2 = \frac{1}{2}\times9.1\times10^{-31}\times171.08\times10^{21}$

K.E. = 778×10^{-19}

Ionisation energy = (13.6) $(z)^2$ = 13.6 × 36 eV = 489.6 eV

$\lambda' = \frac{12400}{489.6} = 25.28\,Å$

5. According to Bohr's theory energy level in an atom is given by

$E = -13.6\frac{z^2}{n^2} = -13.6\times\frac{(3)^2}{n^2}eV$

$\Rightarrow E = -\frac{122.4}{n^2}eV$

So for transition of electron from n = 5 to n = 4

$h\nu = 122.4\left(\frac{1}{4^2} - \frac{1}{5^2}\right) = 2.75$ eV

And for transition of electron from n = 4 to n = 3

$h\nu = 122.4\left[\frac{1}{3^2} - \frac{1}{4^2}\right] = 5.95$ eV

$\therefore K_{max} = hr - \phi$ or $ev_s = h\nu - \phi$

for shorter wavelength($h\nu$) = 5.95 eV

3.95 = 5.95 – ϕ i.e., ϕ = 2eV Ans.

And hence for larger wavelength

eV_s = 2.75 – 2 = 0.75 eV

So the stopping potential for larger wavelength

V_s = 0.75 ev/e = 0.75

6. Given λ_1 = 4144 Å, λ_2 = 4972 Å, λ_3 = 6216 Å, ω = 2.3 eV

Let us first find out which wavelength is capable of ejecting photoelectrons from the metallic surface. For this we calculate here the energy corresponding to each wavelength energy of photon of wavelength λ is

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

$\therefore E_1$ at λ_1 = 4144 Å = 4.8×10^{-19} J

E_2 at λ = 4972 Å = 4×10^{-19} J

E_3 at λ = 6216 Å = 3.2×10^{-19} J

work function $\omega = 3.68\times10^{-19}$ J

As E_1 & $E_2 > \omega$ but $E_3 < \omega$, hence photons of λ_1 & λ_2 only are capable of ejecting electrons because intensity I of the beam of light is distributed equally among three wavelength hence intensity of light corresponding to each wavelength = $\frac{I}{3}$

Intensity = Energy/sec/area.

hence energy incident / sec/ area of the surface corresponding to each wavelength = $\frac{I}{3}$

Hence no. of photon falling / sec/ area of the surface corresponding to wavelength = $\frac{I/3}{hc/\lambda} = \frac{I\lambda}{3hc}$

It A is the surface area then no. of photon in 2 sec.

$\frac{2IA\lambda}{3hc}$

Because each energetically capable photon one electron, hence no. of electrons liberated 2 sec. from area A of the surface by two wavelength λ_1 and λ_2 are given by

$n_1 = \frac{2IA\lambda_1}{3hc}$ & $n_2 = \frac{2IA\lambda_2}{3hc}$

Thus total no. of electrons librate in 2 sec from area A of the metallic surface area

$n = n_1 + n_2 = \frac{2IA}{3hc}(\lambda_1 + \lambda_2)$

Given $I = 3.6\times10^{-3}\,w/m^2$, A = 1 cm^2 λ_1 = 4144 Å

λ_2 = 4972 Å

Hence n = 11×10^{11}

7. Maximum K.E. of photo electron $E_x = \frac{hc}{\lambda} - \omega_0$

Here λ is incident radiation & ω_0 is work function of the surface on which radiation incident

$\therefore$ maximum K.E. of photo electrons emitted by radiation of wavelength λ_1 is given as

$$\frac{1}{2}mv_1^2 = \frac{hc}{\lambda_1} - \omega_0$$

$$mv_1^2 = 2\left(\frac{hc}{\lambda_1} - \omega_0\right) \quad ...(1)$$

m = mass of e^- & v_1 maximum velocity of photo electron similarly of wavelength λ_2

$$\frac{1}{2}mv_2^2 = \frac{hc}{\lambda_2} - \omega_0 \quad ...(2)$$

But $V_2 = 2V_1$ from equation (2)

$$2mv_1^2 = \frac{hc}{\lambda_2} - \omega_0 \quad ...(3)$$

from (1) & (3)

$$4\left(\frac{hc}{\lambda_1} - \omega_0\right) = \frac{hc}{\lambda_2} - \omega_0 \Rightarrow \omega_0 = 3 \text{ eV}$$

But $\omega_0 = \frac{hc}{\lambda_0} \Rightarrow \lambda_0 = \frac{hc}{\omega_0} = 4125$ A°

(iii) In saturation mode, spectral sensitivity with $\lambda_1 = 3000$ Å is J = 4.8 m A/w or 4.8 mc/E. It means when 1 Joule radiation of wavelength $\lambda_1 = 3000$ Å is incident, a charge of 4.8 mc flows an saturation mode of $\frac{4.8\,mc}{e}$ e^- are ejects

Energy of each photon of wavelength λ_1 is $E_1 = \frac{hc}{\lambda_1}$

∴ No of photons in 1 Joule radiation of wavelenth

$$\lambda_1 = \frac{1}{E_1} = \frac{\lambda_1}{hc}$$

No of e^- ejected by these photons = $\frac{J}{e}$

$$= \frac{4.8\times10^{-3}}{1.6\times10^{-19}} = 3 \times 10^{16}$$

∴ efficiency of photo electron genration per incident photon

$$\eta = \frac{3\times10^{16}}{(\lambda_\gamma / hc)} = 0.0198$$

Energy of each photon of λ_2 $E_2 = \frac{hc}{\lambda_2}$

∴ Rate of incidence of photons of λ_2 in power P

$$= \frac{P}{E_2} = \frac{P\lambda_2}{hc} \text{ per second}$$

Since η of photo electron genration is same for both cases,

∴ rate of ejection of electron in later case

$$= \eta\frac{P\lambda_2}{hc} \text{ per second}$$

∴ Rate of flow of charge is current. Hence saturation current in second case 13.2 μA

8. **(a)** Energy of each photon of light (λ = 6000 Å) emitted by the source S is

$$E = \frac{hc}{\lambda} = \frac{(6.63\times10^{-34}\,J-s)\times(3\times10^8\,m/s)}{(6\times10^{-7}\,m)}$$

$= 3.315 \times 10^{-19}$ J

∴ Number of photons emitted per sec by the source

$$N = \frac{\text{Power of Source (P)}}{\text{Energy of one photon } (hc/\lambda)} = \frac{2J/sec}{3.315\times10^{-19}\,J} = 6.03\times10^{18}\,/\text{sec}.$$

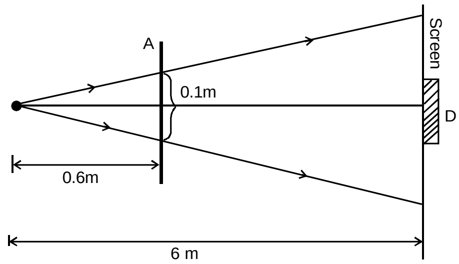
These photons proceed from the source uniformly distributed in all possible directions. Because the aperture A is situated at a distance of 0.6 m (= r) from the source, hence the number of photons reaching per unit area of the aperture in one second is

$$N' = \frac{N}{4\pi r^2} = \frac{6.03\times10^{18}\,/\,sec}{4\pi\times(0.6m)^2}$$

Because the diameter of the aperture is 0.1 m and so its area is $S_A = \pi\,(0.05)^2$. Hence the number of photons passed through the aperture in one second is

$$N_A = N'S_A = \frac{N}{4\pi r^2}\times S_A$$

$$= \frac{6.03\times10^{18}\,/\,sec}{4\pi\times(0.6m)^2}\times\pi(0.05)^2 = 1.047\times10^{16} \text{ per sec.}$$



Now the screen is at a distance of 6m from the source. Suppose the area of the screen illuminated by the light from S be S_a. Then according to the fig, we have

$$\frac{S_s}{\pi(0.05)^2} = \frac{(6m)^2}{(0.6m)^2} \quad \text{or}$$

$S_s = (6/0.6)^2 \times \pi\,(0.05\text{ m})^2 = 0.25\,\pi$ meter^2

The number N_A of the photons tranmitted by the aperture per second fall over this area S_s. Hence the photon flux at the screen (or the number of photons reaching the detector per meter^2 per sec.) is given by

$$N_s = \frac{N_A}{S_s} = \frac{1.047\times10^{16}\text{ photon per sec}}{0.25\times3.14\text{ meter}^2} = 1.33$$

$\times 10^{16}$ photons/meter^2 - sec

Because the efficiency of the detector d is 0.9 and its surface area is 0.5 cm^2 or 0.5×10^{-4} m^2, hence the number of photo-electrons emitted by D in one sec.

$= N_s \times$ area × efficiency

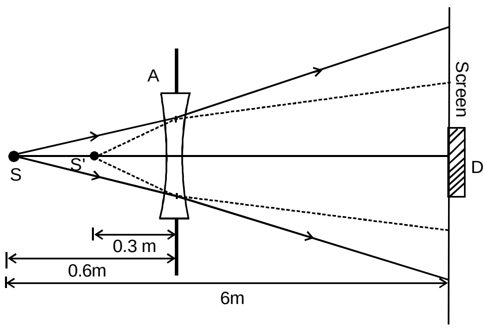
$= (1.33 \times 10^{16}) \times (0.5 \times 10^{-4}) \times 0.9$

$= 0.60 \times 10^{12}$ electrons/sec

The corresponding photo-current in the detector

= $(0.60 \times 10^{12}) \times (1.6 \times 10^{-19}) \times 9.6 \times 10^{-8}$ ampere
= 0.096 micro-ampere

(b) When concave lens is inserted in the aperture, a virtual image S′ of the source S is fomred at a distance of 0.3 m from the lens (by lens formula 1/v – 1/u = 1/f). Since the transmission through the lens is only 80%, the number of photons tranmitted through the lens in one sec is



$N'A = 0.8N_A = 0.8 \times 1.047 \times 10^{16} = 0.838 \times 10^{16}$ per sec.

Suppose now the area of the screen illuminated by the light be S'_s. Then

$$\frac{S'_s}{\pi(0.05\,m)^2} - \frac{(5.7\,m)^2}{(0.3\,m)^2} \quad \text{or}$$

$$S'_s = \frac{(5.7\,m)^2}{(0.3\,m)} \times \pi \times (0.05\ m)^2 = 0.9025\ m^2$$

The N′A photons transmitted in one secthrough the lens fall over the area S'_s. Hence, now the photon flux at the screen is

$$N'_s = \frac{H'A}{S'_s} = \frac{0.838 \times 10^{16}\ \text{photons / sec}}{0.9025 \times 3.14\ m^2}$$

= 2.95×10^{15} photons/meter^2-sec.

Hence phto-current in the detector = N′s × area × efficiency × electronic charge

= $(2.95 \times 10^{15}) \times (0.5 \times 10^{-4}) \times 0.9 \times (1.6 \times 10^{-19})$
= 2.12×10^{-8} ampere
= 0.0212 micro-ampere

(c) The stopping potential is independent of photo current and according to Einstein's photo electric 'euation, in both cases, is given by

$(hc/\lambda) = E_k^{max} + W = eV_0 + W$

or $eV_0 = \frac{hc}{\lambda} - W = \frac{3.315 \times 10^{-19}}{1.6 \times 10^{-19}}$ eV – 1 eV

= 2.07 eV – 1 eV = 1.07 eV

$\therefore$ V_0 = 1.07 volt

The concave lens present in the 2nd case simply changes the intensity of the beam (or the number of photons) but energy of each photons still remains same. Hence in the presence of lens also, the stopping potential will be 1.07 volts.

9. The intensity of light at a distance of 0.1 m from source

$$I = \frac{E}{st} = \frac{P}{S} = \frac{10}{4\pi \times (0.1)^2}$$

area of the target $\pi r^2 = \pi \times (0.05)^2 \times 10^{-8}$

Energy of photon E = $\frac{hc}{\lambda}$ $\Rightarrow E = \frac{hc}{0.5 \times 10^{-9}}$

$\therefore$ Photon flux = $\frac{I}{E} = \frac{5}{16}$ ph / sec

no. of electron emitted = n × photon flux

= $0.01 \times \frac{5}{16} = \frac{5}{1600}$

10. Using Einstein's photoelectric equation for the first case,

$hv = W + \frac{1}{2}mv_1^2 = W_0$ + Ionization energy

= $W_0 + 1.6 \times 10^{-19} \times 13.6 = W_0 + 21.$ i) 76×10^{-19}

For the second case, we have

$$h \times \frac{5}{6}v = W_0 + \frac{1}{2}mv_2^2 = W_0 + \frac{hc}{\lambda}$$

$$= W_0 + \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{1215 \times 10^{-10}}$$

or $\frac{5}{6}hv = W_0 + 16.3 \times 10^{-19}$ ...(ii)

Dividing (i) by (ii), we get

$$\frac{6}{5} = \frac{W_0 + 21.76 \times 10^{-19}}{W_0 + 16.3 \times 10^{-19}}$$

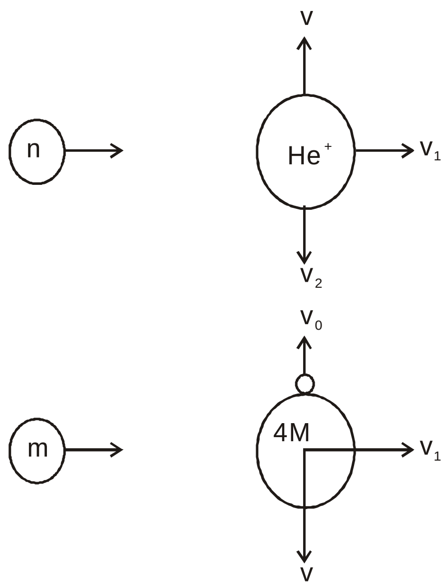
On solving, $W_0 = 11.0 \times 10^{-19}$ joule = 6.875 eV

From equation (i), we have

$$v = \frac{W_0 + 21.76 \times 10^{-19}}{h}$$

$$= \frac{11.0 \times 10^{-19} + 21.76 \times 10^{-19}}{6.6 \times 10^{-34}} = 5 \times 10^{15}\ \text{Hz}$$

11.



(b)

$40.8 \times 10 + 10^{-19} = 6.634 \times 10^{-34} \times f$

9.846×10^{15} Hz

$48.36 \times 1.6 + 10^{-19} = 6.634 \times 10^{-34}$

$f = 11.6 \times 10^{15}$ Hz

$7.56 \times 1.6 \times 10^{-19} = 6.634 \times 10^{-34}$

(a)

$V_\alpha = V/4 \quad \ldots(1)$

$4mv = mv$

$V_\alpha = \dfrac{V}{4} \quad \ldots.(2)$

$\dfrac{1}{2} m v_0^2 - \dfrac{1}{2} 4m \dfrac{v_0^2}{16_4} = \dfrac{3K}{4} = 48.75$

$\therefore$ Passibletrasition is 40.8.

$\Rightarrow$ $f = 18.23 \times 10^{14}$ Hz

Energy left 65 - 40.8 = 24.2 eV

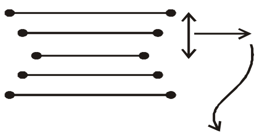
K.E. of He in H - direcn = 1625 eV

24.2 - 16.25 - divided in vertical component of He & necleus

= 7.95

$\dfrac{95 \times 4}{5} \therefore 6.36$ eV

The same way for 48.36 eV

12. 

$102 + 17.00 = 3.4Z^2 - \dfrac{13.6Z^2}{n^2} \ldots\ldots(1)$

$4.25 + 5.95 = \dfrac{13.6}{9} Z^2 - \dfrac{13.6Z^2}{n^2} \ldots(2)$

(1) / (2)

$$\frac{27.2}{10^2} = \frac{\left(\frac{1}{4} - \frac{1}{n^2}\right)}{\left(\frac{1}{9} - \frac{1}{n^2}\right)}$$

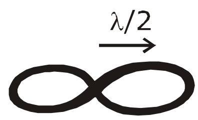
$$\frac{27.2}{9} - \frac{27.2}{n^2} = \frac{102}{4} - \frac{10:2}{n^2}$$

$$\frac{27.2}{9} - \frac{102}{4} = \frac{272 - 10:2}{n^2}$$

$3.02 - 2.55 = \dfrac{17}{n^2}$

$n^2 = 36 \qquad n = 6$

$\therefore \; Z = 3$

13. $2\overset{0}{A} \longrightarrow 2.5$ 

Means $0.5\overset{0}{A} = \lambda/2$

$\Rightarrow \; \lambda = 1\overset{0}{A}$

$\therefore$ Energy :-

$\lambda = \dfrac{h}{\sqrt{2mK.E.}}$

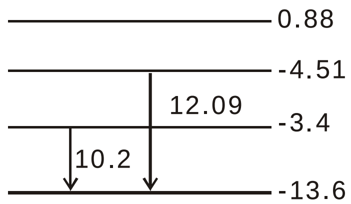
$1 \times 10^{-10} = \dfrac{6.634 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times K.E.}}$

$2 \times 9.1 \times 10^{-31} \times K.E. = 44.01 \times 10^{-48} \times 10^{-17}$

$\Rightarrow \; K.E. = 2.4 \times 10^{-17}$ J

$= \dfrac{2.4 \times 10^{-12}}{1.6 \times 10^{-9}}$

$= 1.5 \times 100 \qquad = 15$ eV

14 

$= \dfrac{1240}{100} = 12.4$eV

$= \dfrac{1240}{200} = 6.2$eV

$\therefore 12.4 \qquad 5eV = 7.4\,eV$ (work Func)

$12.09 - 7.4 = 4.69$ eV

Exercise-IV Level-I

1. C

Work function,

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

[Here they are interested in asking threshold wavelength]

where, h = Planck's constant.
c = velocity of light.

therefore, $\frac{W_{Na}}{W_{cu}} = \frac{\lambda_{cu}}{\lambda_{Na}}$

or $\frac{\lambda_{Na}}{\lambda_{cu}} = \frac{W_{cu}}{W_{Na}}$

$$= \frac{4.5}{2.3} = 2(\text{nearly})$$

2. A

Formation of covalent bonds due to the wave nature of particles is done in compounds.

3. C

Energy required to remove an electron from nth orbit is,

$$E_n = -\frac{13.6}{n^2}$$

Here, n = 2
Therefore,

$$E_2 = -\frac{13.6}{2^2} = -3.4\,V$$

4. A

$$hf = hf_0 + \frac{1}{2}mv^2$$

$$\Rightarrow v_1^2 = \frac{2hf_1}{m} - \frac{2hf_0}{m}$$

$$v_2^2 = \frac{2hf_2}{m} - \frac{2hf_0}{m}$$

$$\therefore v_1^2 - v_2^2 = \frac{2h}{m}[f_1 - f_2]$$

5. B

As $^{133}_{55}Cs$ has larger size among the four atoms given, thus, electrons present in the outermost orbit will be away from the nucleus and the electrostatic force experienced by electrons due to nucleus will minimum. Therefore, the energy required to liberate electrons from outer orbit will be minimum in case of $^{133}_{55}Cs$.

6. C

$$\frac{hc}{\lambda_o} = \phi$$

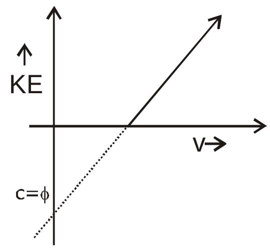
$$\Rightarrow \lambda_{max} = \frac{hc}{\phi}$$

$$= \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{4 \times 1.6 \times 10^{-19}}$$

= 310 nm

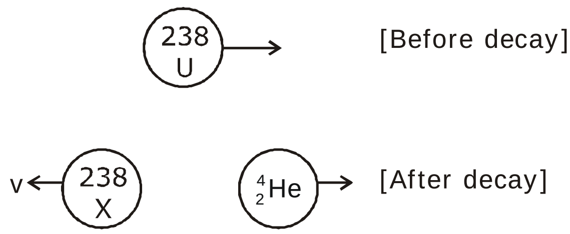
7. D

Einstein's photoelectric equation is
$KE_{max} = h\nu - \phi$



The equation of line is
y = mx + c
Comparing above two equations
m = h, c = -ϕ
Hence, slope of graph is equal to Planck's constant (non-variable) and does not depend on intensity of radiation.

8. C



Apply conservation of linear momentum.
0 = 4u - 234 v

$$\Rightarrow v = \frac{4u}{234}$$

The residual nucleus will recoil with a velocity of $\frac{4u}{234}$ unit.

Note : If they will ask the recoil velocity, then answer remains some ie, $\frac{4u}{234}$ and not - $\frac{4u}{234}$ as the word 'recoil' itself is signifying the direction of motion of residual nucleus.

9. C

We know $\lambda = \frac{h}{mv}$

and $K = \frac{1}{2}mv^2 = \frac{(mv)^2}{2m}$

$\Rightarrow mv = \sqrt{2mK}$

Thus, $\lambda = \frac{h}{\sqrt{2mK}} \Rightarrow \lambda \propto \frac{1}{\sqrt{K}}$

$\Rightarrow \frac{\lambda_1}{\lambda_2} = \frac{\sqrt{K_1}}{\sqrt{K_2}} = \frac{\sqrt{K_1}}{\sqrt{2K_1}}$ $(\therefore K_2 = 2K_1)$

or $\frac{\lambda_1}{\lambda_2} = \frac{1}{\sqrt{2}}$ or $\lambda_2 = \frac{\lambda_1}{\sqrt{2}}$

10. B

$\frac{I_2}{I_1} = \frac{(r_1)^2}{(r_2)^2}$ $\left(\text{as } I \propto \frac{1}{r^2}\right)$

$\Rightarrow \frac{I_2}{I_1} = \frac{(1)^2}{\left(\frac{1}{2}\right)^2}$

$I_2 = 4I_1$

Now, since number of electrons emitted per second is directly proportional to intensity, so number of electrons emitted by photo-cathode would increase by a factor of 4.

11. A

$E = Rhc\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$E_{(4\to3)} = Rhc\left[\frac{1}{3^2} - \frac{1}{4^2}\right] = 0.05Rhc$

$E_{(4\to2)} = Rhc\left[\frac{1}{2^2} - \frac{1}{4^2}\right] = 0.2Rhc$

$E_{(2\to1)} = Rhc\left[\frac{1}{(1)^2} - \frac{1}{(2)^2}\right] = 0.75Rhc$

$E_{(1\to3)} = Rhc\left[\frac{1}{(3)^2} - \frac{1}{(1)^2}\right] = -0.9Rhc$

Thus, III transition gives most energy. I transition represents the absorption of energy.

12. D

According to the photoelectric effect in a photocell, if a light of wavelength λ is incident on a cathode, then electrons are emitted, which constitute the photoelectric current.

Photocell is based on the principle of photoelectric effect. As the wavelength of light changes, there is no change in number of electrons emitted and hence, no change in current (Plate current of photocell). Thus, the two wavelength of incident light and plate current are independent to each other.

Plate current depends on intensity of light used.

Note : Here no option is matching.

13. B

The photoelectric effect is an instantaneous phenomenon (experimentally proved). It takes approximate time of the order of 10^{-10} s.

14. A

$hv_0 = 6.2$ eV, $eV_0 = 5$ eV

From Einstein's photoelectric equation

$hv = hv_0 + eV_0 = 6.2 + 5 = 11.2$ eV

$\Rightarrow \frac{hc}{\lambda} = 11.2\,\text{eV}$

or $\lambda = \frac{hc}{11.2} = 1108.9\,\overset{0}{A}$

Which belongs to ultra - violet region.

15. D

The momentum of the photon

$P = \frac{h}{\lambda} = \frac{hv}{c}$

16. C

Emission spectrum would rises when electron makes a jump from higher energy levels to lower energy level,

Frequency of emitted photon is proportional to change in energy of two energy levels, ie,

$v = RcZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

17. B

For constructive interference,

$2d\cos i = n\lambda = \frac{h}{\sqrt{2meV}}$

On substituting values, we get,

$V \approx 50$ volt

18. B

Expression is given by 2 d cos i = $n\lambda d_B$.

19. D

As diffraction pattern has to be wider than slit width, so (d) is the correct option.

20. B

$\frac{mv^2}{r_n} = \frac{k}{r_n}$ given

$mvr_n = \frac{nh}{2\pi}$ from Bohr's theory.

on solving, $r_n \propto n$ and T_n is independent of n.

21. B

$\frac{1}{2}mv^2 = eV_o = 1.68\,eV$

$\Rightarrow hv = \frac{hc}{\lambda} = \frac{1240\,ev\,nm}{400\,nm} = 3.1\,eV$

$\Rightarrow$ 3.1 eV = W_0 + 1.6 eV

W_0 = 1.42 eV

22. D

IR corresponds to least value of $\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

i.e., from Paschen, Bracket and Pfund series. Thus the transition corresponds to 5→3

23. A

$4 \times 10^3 = 10^{20} \times hf$

$f = \frac{4 \times 10^3}{10^{20} \times 6.023 \times 10^{-34}}$

$f = 6.64 \times 10^{16}$ Hz

The obtained frequency lies in the band of X-rays.

24. C

$K_{max} = eV_o = h(v - v_o)$

If V' = 2v

$\therefore \quad K'_{max} = eV'_0 = h(2v - v_o)$

$= 2K_{max} + hv_0$

$\therefore \quad K'_{max} > 2K_{max}$ and

$\Rightarrow \quad v'_0 > 2v_0$

25. B

$\Delta E = 13.6\,Z^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

$= 13.6(3)^2\left(\frac{1}{1^2} - \frac{1}{3^2}\right)$

= 108.8 eV

26. D

de- Broglie wavelength $\lambda = \frac{h}{mv} = \frac{h}{P}$,

Where P = momentum

By conservation of momentum

$\vec{P}_1 + \vec{P}_2 = 0$

or $\quad P_1 = P_2$

$\therefore \quad \lambda_1 = \lambda_2 = \lambda$

27. C

Davission and Germer experimentally established wave nature of electron by observing diffraction pattern while bombarding electrons on Ni crytal.

28. D

In emission spectrum number of bright lines is given by

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

29. D

Rotational kinetic energy of the two body system rotating about their centre of mass is

$RKE = \frac{1}{2}\mu\omega^2 r^2$,

where $\mu = \frac{m_1 m_2}{m_1 + m_2}$ = reduced mass

and angular momentum, $L = \mu\omega r^2 = \frac{nh}{2\pi}$

$RKE = \frac{1}{2}\mu\omega^2 r^2$,

$= \frac{1}{2}\mu.\left(\frac{nh}{2\pi\mu r^2}\right)^2 r^2$

$= \frac{n^2h^2}{8\pi^2\mu r^2} = \frac{n^2h^2}{2\mu r^2}$

$= \frac{(m_1 + m_2)n^2h^2}{2m_1m_2r^2}$

30. B

Energy $\propto \frac{1}{\lambda}$

31. B

Energy $\propto \frac{1}{n^2}$

$h\nu \propto \frac{1}{(n-1)^2} - \frac{1}{n^2}$

$h\nu \propto \frac{n^2 - (n-1)^2}{(n-1)^2(n)^2} = \frac{2n-1}{n^2(n-1)^2} \cong \frac{2n}{n^2(n)^2}$

$\Rightarrow h\nu \propto \frac{1}{n^3}$

Exercise-IV Level-II

1. A

(a) In hydrogen atom

$E_n = -\frac{Rhc}{n^2}$ Also $E_n \propto m$

where m is the mass of the electron. Here the electron has been replaced by a particle whose mass is double of an electron. Therefore, for this hypothetical atom energy in nth orbit will be given by -

$E_n = -\frac{2Rhc}{n^2}$

The longest wavelength λ max (or minimum energy) photon will correspond to the transition of particle from n = 3 to n = 2

$\therefore \frac{hc}{\lambda_{max}} = E_3 - E_2 = Rhc\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$

This gives $\lambda_{max} = \frac{18}{5R}$

(b) $v_n \rightarrow \frac{1}{n}$

$\therefore KE \propto \frac{1}{n^2}$ (with positive sign)

Potential Energy U is negative and $U_n \propto \frac{1}{r_n}$

$\left[U_n = -\frac{1}{4\pi\epsilon_0} \cdot \frac{Ze^2}{r_n}\right] \alpha \frac{1}{n^2}$

[because $r_n \propto n_2$] (with negative sign)

Similarly total energy $E_n \propto \frac{1}{n^2}$ (with negative sign)

Therefore, when an electron jumps from some excited state to the ground state, value of n will decrease. Therefore kinetic energy will increase (with positive sign), potential energy and total energy will also increase but with negative sign. Thus, finally kinetic energy will increase, while potential and total energies will decrease.

$\rightarrow$ (i) For hydrogen and hydrogen-like atoms

: $E_n = -13.6\frac{Z^2}{n^2}$ eV

, $U_n = 2En = -27.2\frac{Z^2}{n^2}$ eV and

$K_n = |E_n| = 13.6 \frac{Z^2}{n^2}$ eV

From these three relations we can see that as n decreases, K_n will increase but E_n and U_n will decrease (ii) As an electron comes closer to the nucleus, the electrostatic froce (which provides the necessary centripetal force) increases or speed (or KE) of the electron increases.

2. **(a)**

Let ground state energy (in eV) be E_1 Then from the given condition.

$E_{2n} - E_1 = 204$ eV or $\frac{E_1}{4n^2} - E_1 = 204$ eV or

$E_1\left(\frac{E_1}{4n^2} - 1\right) = 204$ eV

and $E_{2n} - E_n = 40.8$ eV or $\frac{E_1}{4n^2} - \frac{E_1}{n^2} = 40.8$ eV

or $E_1\left(\frac{-3}{4n^2}\right) = 40.8$ eV

From equation number (1) and (2)

$\frac{1 - \frac{1}{4n^2}}{\frac{3}{4n^2}} = 5$ or $1 = \frac{1}{4n^2} + \frac{15}{4n^2}$ or $\frac{4}{n^2} = 1$

or n = 2

From equation number (2)

$E_1 = -\frac{4}{3}n^2(40.8)$ eV $= -\frac{4}{3}(2)^2(40.8)$ eV

or $E_1 = -217.6$ eV, $E_1 = -(13.6) Z^2$

$\therefore\ Z^2 = \frac{E_1}{-13.6} = \frac{-217.6}{-13.6} = 16 \qquad Z = 4$

$E_{min} = E_{2n} - E_{2n-1} = \frac{E_1}{4n^2} - \frac{E_1}{(2n-1)^2}$

n = 2

$= \frac{E_1}{16} - \frac{E_1}{9} = -\frac{7}{144}E_1 = -\left(\frac{7}{144}\right)(-217.6)$

eV $\therefore E_{min} = 10.58$ eV

(b) Energy of incident photon, $E_1 = 10.5$ eV = $10.6 \times 1.6 \times 10^{-19}$ J = 16.96×10^{-19} J

Energy incident per unit area per unit time (intensity) = 2J

$\therefore$ Number of photons incident on unit area in

unit time = $\frac{2}{16.96 \times 10^{-19}} = 1.18 \times 10^{18}$

Therefore, number of photon incident per unit time on given area (1.0×10^{-4} m^2) = (1.18×10^{18}) (1.0×10^{14}) = 1.18×10^{14}

But only 0.53% of incident photons emit photoelectrons

$\therefore$ Number of photoelectrons emitted per second (n)

$n = \left(\frac{0.53}{100}\right)(1.18 \times 10^{14})$ or n = 6.25×10^{11}

$K_{min} = 0$

and $K_{max} = E_i$ – work function = (10.6 – 5.6) eV = 5.0 eV $\qquad \therefore K_{max} = 5.0$ eV

3. D

Minimum wavelength of continuous X-ray spectrum is given by -

λ_{min} (in Å) $= \frac{12375}{E(\text{in eV})}$

Here, E = energy of incident electrons (in eV) = energy corresponding to minimum wavelength λ_{min} of X-rays

E = 80 keV = 80×10^3 eV

$\therefore \lambda_{min}$ (in Å) $= \frac{12375}{80 \times 10^3} \approx 0.155$

Also the energy of the incident electrons (80 keV) is more than the ionization energy of the K-shell electrons (i.e. 72.5 eV). Therefore, characteristic X-ray spectrum will also be obtained because energy of incident electron is high enough to knock out the electron from K or L shells.

4. D

Energy of infrared radiation is less than the energy of ultraviolet radiation. As 'n' Increases energy difference between successive levels decreases.

5. A

Wavelength λ_k is independent of the accelerating voltage (V), while the minimum wavelength λ_c is inversely proportional to V.

6. A

$i = \frac{q}{t} = \frac{ne}{t} \qquad \therefore n = \frac{it}{e}$

substituting i = 3.2×10^{-3} A

e = 1.6×10^{-19}C and t = 1 s

we get n = 2×10^{16}

7. B

In second excited state n = 3

so $l_H = l_{Li} = 3\left(\frac{h}{2\pi}\right)$

while $E \propto Z^2$ and $Z_H = 1 \quad Z_{Li} = 3$

so $|E_{Li}| = 9\,|E_H|$ or $|E_H| < |E_{Li}|$

8. (a)

Total 6 lines are emitted. Therefore.

$\frac{n(n-1)}{2} = 0$ or n = 4

So, transition is taking between mth energy state and (m + 3)th energy state.

$\therefore\ E_m = -0.85$ eV or $-13.6\left(\frac{Z^2}{m^2}\right) = -0.85$

or $\frac{z}{m} = 0.25$

...(1)

Similarly $E_{m+3} = -0.544$

$-13.6\left(\frac{Z^2}{(m+3)^2}\right) = -0.544$ or $\frac{z}{(m+3)} = 0.2$ ...(2)

Solving equation (1) and (2) for z and m we get,

m = 12 and z = 3 Ans.

(b)

(b) Smallest wavelength corresponds to maximum difference of energies which is obviously

$E_{m+3} - E_m$

$\therefore\ \Delta E_{max} = -0.544 - (-0.85) = 0.306$ eV

$\therefore\ \lambda_{min} = \frac{hc}{\Delta E_{max}} = \frac{1240}{0.306} = 4052.3\text{nm}$

9. (a)

Area of Plates A = 5×10^{-4} m^2

distance between the plates d = 1 cm = 10^{-2} m

$$n = \frac{(\text{number of photons falling in unit area in unit time}) \times (\text{Area} \times \text{time})}{10^6}$$

$= \frac{1}{10^6}[(10)^{16} \times (5\times10^{-4}) \times (10)]$ = 5.0 × 10^7

(b)

At time t = 10 s

charge on plate A, q_A = + ne = (5.0 × 10^7) (1.6 × 10^{-19}) = 8.0 × 10^{-12} C

and charge on plate B, q_B = (33.7 × 10^{-12} – 8.0 × 10^{-12}) = 25.7 × 10^{-12} C

∴ Electric field between the plates

$E = \frac{(q_B - q_A)}{2A\varepsilon_0}$

or $E = \frac{(25.7-8.0)\times10^{-12}}{2\times(5\times10^{-4})(8.85\times10^{-12})}$ = 2 × 10^3 $\frac{N}{C}$

(c) Energy of photoelectrons at plate A = E – W = (5 –2) eV = 3 eV

Increase in energy of photoelectrons = (eEd) Joule = (Ed) eV

= (2 × 10^3) (10^{-2}) eV = 20 eV

Energy of photoelectrons at plate B = (20 + 3) eV = 23 eV

10. D

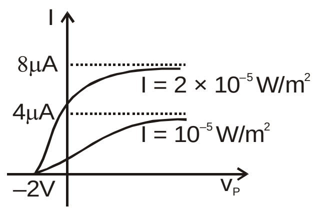
Bohr's radius $r_n \propto \frac{1}{Z}$

11. A

Force between proton & electron is conservative $F = \frac{du}{dx}$ and provides the necessary force for electron motion.

12. Energy of the x-rays produced is equal to the difference of the energy levels of the shell in which electron transition occurs.

13. Stopping potential = $\frac{(5-3)}{e}$ eV



14. A

Saturation current is proportional to intensity while stopping potential increases with increase in frequency Hence $f_a = f_b$ while $I_a < I_b$ therefore, the correct option is (a)

15. B

$\frac{\lambda_1}{\lambda_2} = \frac{\frac{h}{\sqrt{2mE}}}{\frac{hc}{E}}$ or $\frac{\lambda_1}{\lambda_2} \propto E^{1/2}$

Therefore, the correct option is (B)

16. Wavelengths corresponding to minimum wavelength (λ_{min}) or maximum energy will emit photoelectrons having maximum kinetic energy.

(λ_{min}) belonging to Balmer series and lying in the given range (450 nm to 750 nm) corresponds to transition from (n = 4 to n =2). Here,

$E_4 = \frac{13.6}{(4)^2}$ = –0.85 eV and $E_2 = -\frac{13.6}{(2)^2}$

= –3.4 eV

∴ ΔE = $E_4 - E_2$ = 2.55 eV

K_{max} = Energy of photon – work function = 2.55 – 2.0 = 0.55 eV

17. C

For $K_a \Rightarrow \sqrt{v} \propto (z-1) \Rightarrow \frac{1}{\sqrt{\lambda}} \propto (z-1)$

or $\lambda \propto \frac{1}{(z-1)^2}$ ...(i), $4\lambda \propto \frac{1}{(z'-1)^2}$ ...(ii)

$\Rightarrow \frac{1}{4} = \frac{(z'-1)^2}{(z-1)^2} \Rightarrow \frac{z'-1}{z-1} = \frac{1}{2} \Rightarrow 2z' - 2$

= z – 1 ⇒ 2z' – 2 = 11 – 1 = 10 ⇒ z′ = 6

18. A

First photon will excite the atom to I excited state, which when returning to ground state will emit a photon of energy 10.2 eV second photon will ionize the atom (13.6 eV will be used up in this process). The extra energy (=15 – 13.6 = 1.4 eV) will be carried by electron as its K.E. So a photon of energy 13.6 eV and an electron of energy 1.4 eV will be emitted.

19. B

20. For 0 ≤ x ≤ 1, KE = $2E_0 - E_0 = E_0$

for x > 1, KE = $2E_0$

$\frac{\lambda_1}{\lambda_2} = \frac{h/P_1}{h/P_2} = \frac{P_2}{P_1} = \sqrt{\frac{KE_2}{KE_1}} = \sqrt{\frac{2E_0}{E_0}} = \sqrt{2}$

21. (a) Using R = R_0 $(A)^{1/3}$ $(14)^{1/3} = \left(\frac{A}{4}\right)^{1/3}$

⇒ A = 14 × 4 = 56

∴ Z = A – N = 56 – 30 Z = 26

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

$\Rightarrow v = \frac{c}{\lambda} = Rc(Z-1)^2\left(\frac{1}{1^2} - \frac{1}{2^2}\right)$

= 1.1 × 10^7 × 3 × 10^8 × $(26-1)^2$ $\left(\frac{3}{4}\right)$

= 1.1 × 3 × 625 × $\frac{3}{4}$ × 10^{15}

$= 9.9 \times 625 \times 25 \times 10^{13} = 154875 \times 10^{12}$ Hz

22. AC

Stopping potential is given by

$$v = \frac{hc}{e}\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right) = 12400\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)$$

$\Rightarrow \lambda$ = wavelength in Å

λ_0 = Threshold value of wavelength for a particular metal.

23. Compare the wavelength of the transition from $(n + 1)^{th}$ to first n = 1 of the ion to the de-broglie wavelength in its first orbit.

24. B

both statements are correct but statement (2) is not correct explanation of statement (1).

Energy of characterstic X-ray depends on the difference in energy levels.

25. A

$$p = \frac{h}{\lambda} \Rightarrow K.E. = \frac{p^2}{2m} = \frac{h^2}{2m\lambda^2}$$

If entire K.E. of electron is converted into photon then

$$\frac{h^2}{2m\lambda^2} = \frac{hc}{\lambda_0} \Rightarrow \lambda_0 = \frac{2mc\lambda^2}{h}$$

26. B

The series in uv region is Lyman series. Longest wavelength corresponds to minimum energy which occurs in transition from n = 2 to n = 1.

$$\therefore \quad 122 = \frac{1/R}{\frac{1}{1^2} - \frac{1}{2^2}} \qquad ....(1)$$

The smallest wavelength in the infrared region corresponds to maximum energy of Paschen series

$$\lambda = \frac{1/R}{\frac{1}{3^2} - \frac{1}{\infty}} \qquad ...(2)$$

from (1) and (2) λ = 823.5 nm.

27. B

$$\lambda_{cutoff} = \frac{hc}{ev}$$

(independent of atomic number)

28. C

29. C

$E_4 - E_3 = \dfrac{hc}{\lambda}$ [I : visible region]

30. A

$$KE \propto Z^2/n^2 \Rightarrow \quad \frac{KE_H}{KE_{He}} = \left(\frac{Z_H}{2} / \frac{Z_{He}}{2}\right)^2 = \frac{1}{4}$$

31. A

32. B

33. D

$$E = \frac{P^2}{2m}, \quad p = \frac{h}{\lambda} \quad ; \quad \frac{n\lambda}{2} = a, \quad E = \frac{n^2h^2}{4a^2.2m} = \frac{1}{2}mv^2$$

34. A

Wavelength have energies 2.25 eV, 2.75 eV, 3.5 eV.

$\therefore$ In *P*, all cause emission, in *q*, only last two & in *r*, only last $\therefore I_P > I_q > I_r$.

35. $\therefore \lambda = \dfrac{h}{\sqrt{2mv}} \Rightarrow \dfrac{\lambda_p}{\lambda_\alpha} = \sqrt{\dfrac{m_\alpha \times q_\alpha}{m_p \times q_p}} = \sqrt{8} \approx 3$

36. D

$$\text{Rotational energy} = \frac{L^2}{2I} = \frac{n^2h^2}{4\pi^2 \times 2I} = \frac{n^2h^2}{8\pi^2 I}$$

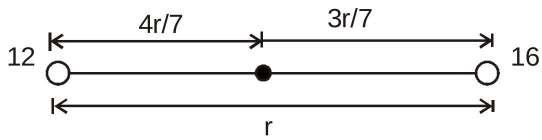
37. B

$$\frac{L_F^2}{2I} - \frac{L_i^2}{2I} = hf$$

$$\Rightarrow \frac{h}{4\pi^2 2I}[4-1] = f \Rightarrow I = 1.87 \times 10^{-46}\ \text{kgm}^2$$

38. C

$I_{cm} = I_c + I_0$



$$\Rightarrow 12 \times \left(\frac{4r}{7}\right)^2 + 16 \times \left(\frac{3r}{7}\right)^2 = \frac{1.87 \times 10^{-46}}{1.63 \times 10^{-27}}$$

$\Rightarrow r = 1.3 \times 10^{-10}$

39. A

$$\text{Given } \frac{1}{\lambda_1} = Rz^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

$$\Rightarrow \frac{1}{6561} = R(1)^2\left[\frac{1}{4} - \frac{1}{9}\right] \Rightarrow R = \frac{36}{6561 \times 5}$$

$$\text{Now } \frac{1}{\lambda_2} = R(2)^2\left[\frac{1}{4} - \frac{1}{16}\right]$$

$$\lambda_2 = \frac{16 \times 4}{R \times 4 \times 12} = \frac{16 \times 4 \times 6561 \times 5}{36 \times 4 \times 12}$$

$\Rightarrow \lambda_2 \approx$ 1215 Å

40. w.f = 4.7 eV

$E = \frac{hc}{\lambda} = 6.2$ eV

energy of emited e^- = 1.5 eV

$\Rightarrow$ i.e., when potential of the sphere is 1.5 V then no e^- emited

$\Rightarrow \frac{KQ}{R} = 1.5 \Rightarrow \frac{9 \times 10^9 \times Q}{1 \times 10^{-2}} = 1.5$

$\Rightarrow Q = \frac{1.5}{9} \times 10^{-11}$ No. of e^-

$= \frac{1.5 \times 10^{-11}}{9 \times 1.6 \times 10^{-19}} = \frac{150}{9 \times 16} \times 10^7 \Rightarrow Z = 7$

41. KE = PE $\Rightarrow \frac{1}{2}mv^2 = \frac{kq_1q_2}{r}$

$\frac{p^2}{2m} = \frac{9 \times 10^9 \times e \times 120e}{10 \times 10^{-15}}$

& $\lambda = \frac{h}{p}$ (from debroglie)

solving $\lambda = 7 \times 10^{-15} = 7$ fm