MID ASSIGNMENT

Name: Romona Magdalene Sarkar

ID: 20-42186-1

Sec: I

Assignment

1) Calculate the wavelength of light emitted from the hydrogen atom when the electron undergoes a transition from level $n=3$ to level $n=1$. What is the name of the series produced by this transition? What will be the wave number for this transition? What will be the frequency?

Sol: Here given that, $n_1 = 1$

$n_2 = 3$

We know that,

$$\frac{1}{\lambda} = \frac{2\pi^2 m e^4}{h^3 c}\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

or $\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$ where R is the Rydberg constant having value $109,676\ cm^{-1}$

Putting the values we get,

$$\frac{1}{\lambda} = 109676\left[\frac{1}{1^2} - \frac{1}{3^2}\right] cm^{-1}$$

or, $\frac{1}{\lambda} = 109676\left[1 - \frac{1}{9}\right] cm^{-1}$

or, $\frac{1}{\lambda} = 109676 \times \frac{8}{9}\ cm^{-1}$

$$\lambda = \frac{9}{8 \times 109676}\ cm$$

$= 1.025 \times 10^{-5}\ cm$

or, $1.025 \times 10^{-7}\ m$ (Ans).

Since, the electron is falling on to $n_1 = 1$ from upper level so it will produce Lyman series.

Wave number, $\bar{\nu} = \frac{1}{\lambda}$

$= 97489.77\ cm^{-1}$

Frequency, $\nu = \frac{c}{\lambda}$ where c = velocity of light $= 3 \times 10^8\ ms^{-1}$

So, $\nu = \dfrac{3 \times 10^8}{1.025 \times 10^{-7}}$ Hz

$= 2.9268 \times 10^{15}$ Hz

2. What is the difference in energy between the two levels of the sodium atom if emitted light has a wave length of 589 nm?

Sol: Given that, $\lambda = 589$ nm

$= 589 \times 10^{-9}$ m

$h = 6.62 \times 10^{-34}$ Js

$c = 3 \times 10^8$ ms^{-1}

We know that, $\Delta E = E_{n_2} - E_{n_1}$

$= h\nu$

So, $\Delta E = E_{n_2} - E_{n_1} = h\dfrac{c}{\lambda}$

$\Delta E = \dfrac{6.62 \times 10^{-34} \times 3 \times 10^8}{589 \times 10^{-9}}$ Joule

$= 3.3718 \times 10^{-19}$ Joule.

3. The green line in the atomic spectrum of thallium has a wave length of 535nm. Calculate the energy of a photon of this line.

Sol: We know that,

$$E = h\nu = h\frac{c}{\lambda}$$

$$= \frac{6.62 \times 10^{-34} \times 3 \times 10^{8}}{535 \times 10^{-9}} \text{ Joule}$$

$$= 3.712 \times 10^{-19} \text{ Joule.}$$

(Ans).

4. An electron in a hydrogen atom level $n = 5$ undergoes a transition to level $n = 3$. What is the frequency of the emitted radiation?

Solⁿ: Here given that,

$n_1 = 3 \quad n_2 = 5$

We know that, $\frac{1}{\lambda} = \frac{2\pi^2 me^4}{h^3 c}\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

or, $\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$ where R is the Rydberg constant having value 109,676 cm^{-1}.

Putting the values we get,

$$\frac{1}{\lambda} = 109676\left[\frac{1}{3^2} - \frac{1}{5^2}\right] cm^{-1}$$

$$\text{or, } \frac{1}{\lambda} = 109676\left[\frac{1}{9} - \frac{1}{25}\right] cm^{-1}$$

$$\text{or, } \frac{1}{\lambda} = 109676 \times \frac{16}{225}\ cm^{-1}$$

$$\therefore \lambda = \frac{225}{16 \times 109,676}\ cm$$

$$= 1.282 \times 10^{-4}\ cm$$

$$= 1.282 \times 10^{-6}\ m.$$

Now the frequency $\nu = \frac{c}{\lambda}$ where, c = velocity of light $= 3 \times 10^8\ ms^{-1}$

$$\therefore \nu = \frac{3 \times 10^8}{1.282 \times 10^{-6}}\ Hz$$

$$= 2.34 \times 10^{14}\ Hz \quad \text{(Ans)}$$

5) Calculate the longest wavelength of the electromagnetic radiation emitted by the hydrogen atom in undergoing a transition from the $n = 6$ level.

Solution: For being the longest wavelength of the electromagnetic radiation emitted by the hydrogen atom due to a transition from the $n = 6$ level, energy should be very small. So, it can be said that transition from the $n=6$ to $n=5$ level will be lower energy transition. Where transition from the $n=6$ to $n=1$ energy will be higher.

So, for longest wavelength, $n_1 = 5, n_2 = 6$

We know that, $\frac{1}{\lambda} = \frac{2\pi^2 m e^4}{h^3 c}\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

or, $\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$ where R is the Rydberg constant having value 109,676 cm^{-1}.

Putting the values we get,

$$\frac{1}{\lambda} = 109676\left[\frac{1}{5^2} - \frac{1}{6^2}\right] cm^{-1}$$

$$\text{or, } \frac{1}{\lambda} = 109676\left[\frac{1}{25} - \frac{1}{36}\right] cm^{-1}$$

$$\text{or, } \frac{1}{\lambda} = 109676 \times \frac{11}{900}\ cm^{-1}$$

$$\therefore \lambda = \frac{900}{11 \times 109676}\ cm$$

$$= 7.459 \times 10^{-4}\ cm$$

$$= 7.459 \times 10^{-6}\ m$$

Ans: 7.459×10^{-6} m.

6. Calculate the shortest wavelength of the electromagnetic radiation emitted by the hydrogen atom in undergoing a transition from the $n=6$ level.

Solution:

For being the shortest wavelength of the ~~ex~~ electromagnetic radiation emitted by the hydrogen atom due to a transition from the $n=6$ level, energy should be high.

So, it can be said that transition from the $n=6$ to $n=1$ level will be higher energy transition.

Where transition from the $n=6$ to $n=5$ energy will be lower.

Scanned with CamScanner

So, for shortest wavelength, $n_1 = 1$ and $n_2 = 6$

We know that,

$$\frac{1}{\lambda} = \frac{2\pi^2 me^4}{h^3 c}\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

or, $\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$ where R is the Rydberg constant having value 109,676 cm^{-1}.

Putting the values we get,

$$\frac{1}{\lambda} = 109676\left[\frac{1}{1^2} - \frac{1}{6^2}\right] cm^{-1}$$

$$\Rightarrow \frac{1}{\lambda} = 109676\left[1 - \frac{1}{36}\right] cm^{-1}$$

or, $\frac{1}{\lambda} = 109676 \times \frac{35}{36}\ cm^{-1}$

or, $\lambda = \frac{36}{35 \times 109,676}\ cm$

$= 9.378 \times 10^{-6}\ cm$

$= 9.378 \times 10^{-8}\ m.$

Ans: $\lambda = 9.378 \times 10^{-8}\ m.$

Scanned with CamScanner

7) A line of the Lyman series of the hydrogen atom spectrum has the wavelength 9.50×10^{-8} m. It results from a transition from upper energy level. What is the principle quantum number of that upper level?

Solution:

Since line is of the Lyman series so $n_1 = 1$ and $n_2 = ?$

Here, $\lambda = 9.50 \times 10^{-8}$ m

$= 9.50 \times 10^{-6}$ cm

[Since Rydberg constant is in cm^{-1} unit so we are taking wavelength in cm unit]

We know that,

$$\frac{1}{\lambda} = \frac{2\pi^2 m e^4}{h^3 c}\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

or, $\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$ where R is the Rydberg constant having value 109,676 cm^{-1}

Putting the values we get,

$$\frac{1}{9.50 \times 10^{-6}} = 109676\left[\frac{1}{1^2} - \frac{1}{n_2^2}\right]$$

or, $\frac{1}{109676 \times 9.50 \times 10^{-6}} = \left[1 - \frac{1}{n_2^2}\right]$

or, $\frac{1}{n_2^2} = \left[1 - \frac{1}{109676 \times 9.5 \times 10^{-6}}\right]$

or, $\frac{1}{n_2^2} = \left[1 - 0.959764742\right]$

or, $\frac{1}{n_2^2} = 0.040235257$

or, $n_2^2 = 24.8538$

$n_2 = \sqrt{24.8538}$

$n_2 = 4.98 \approx 5$

Ans: $n_2 = 5$.

8. A line of the Balmer series of the hydrogen atom spectrum has the wavelength 397 nm. It results from a transition from upper energy level. What is the principle quantum numbers of that upper level?

Solution:

Since line is of the Balmer series

so, $n_1 = 2$ and $n_2 = ?$ Here, $\lambda = 397 nm$
$= 397 \times 10^{-7} cm$

[Since Rydberg constant is in cm^{-1} unit so we are taking wavelength in cm unit]

We know that, $\frac{1}{\lambda} = \frac{2\pi^2 m e^4}{h^3 c}\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

or, $\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$ where R is the Rydberg constant having value 109,676 cm^{-1}

Putting the values we get,

$$\frac{1}{397\times10^{-7}} = 109676\left[\frac{1}{2^2} - \frac{1}{n_2^2}\right]$$

or, $\frac{1}{397\times10^{-7}\times109676} = \left[\frac{1}{4} - \frac{1}{n_2^2}\right]$

or, $\frac{1}{n_2^2} = \frac{1}{4} - \frac{1}{109676\times397\times10^{-7}}$

or, $\frac{1}{n_2^2} = \frac{1}{4} - 0.2296666$

or, $\frac{1}{n_2^2} = 0.0203333$

or, $n_2^2 = 49.18$

or, $n_2 = \sqrt{49.18}$

$n_2 = 7.01 \approx 7$ (Ans)

Scanned with CamScanner

9. State which of the following sets of quantum numbers would be possible and which would be impossible for an electron in an atom.

a) $n=0, l=0, m=0, s=+1/2$

[Impossible]

b) $n=1, l=1, m=0, s=+1/2$

[Impossible]

c) $n=1, l=0, m=0, s=-1/2$

[Possible]

d) $n=2, l=1, m=-2, s=+1/2$

[Impossible]

e) $n=2, l=1, m=-1, s=+1/2$

[Possible]

Scanned with CamScanner

10. State which of the following sets of quantum numbers is ~~poss~~ permissible for an electron in an atom. If a set is not permissible, explain why?

a) $n=1, l=1, m=0, s=+1/2$

Impossible, because here, $l=n$ but we know that l and n can't be equal. The range of l is 0 to $n-1$.

b) $n=3, l=1, m=-2, s=-1/2$

Ans: Impossible because here $m=-2$. The range of m is from $-l$ to l but here it is -2.

c) $n=2; l=1, m=0, s=+1/2$

Ans: Possible.

d) $n=2, l=0, m=0, s=1$

Ans: Impossible, because s can only be $-1/2$ or $+1/2$.

e) $n = 3, l = 2, m = 3, s = +\frac{1}{2}$

Ans: Impossible, because m is not in the range of $-l$ to l.

f) $n = 3, l = 2, m = -2, s = 0$

Ans: Impossible s can't be 0. It must be $-\frac{1}{2}$ or $+\frac{1}{2}$.