Atomic Structure DPP-5 Solutions

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Referral Code: ABSIRLIVE

1. **$5.8 \times 10^{-5}\ m^2\ s^{-1}$.**

Sol. We have,

$\Delta x.\ \Delta p = \frac{h}{4\pi}$

$\Delta x.\ (m\ \Delta v) = \frac{h}{4\pi}$

or $\Delta x\ .\ \Delta v = \frac{h}{4\pi m}$

$= \frac{6.62\times10^{-34}(kg.m^2s^{-1})}{4\times3.14\times(9.10\times10^{-31}kg)}$

$= 5.8 \times 10^{-5}\ m^2s^{-1}$.

2. **(a) $\approx 3 \times 10^{-30}$ metre. (b) $\approx 3 \times 10^{-5}$ meter**

Sol. (a) The velocity has an uncertainty of 0.02 m/s. (from 0.99 to 1.01 m/s)

$\therefore \Delta x = \frac{h}{4\pi m\Delta v} = \frac{6.63\times10^{-34}(J.s)}{(4\times3.14)(1\times10^{-3}kg)\,(0.02\,m/s)}$

$\approx 3\times10^{-30}$ metre.

(b) $\Delta x = \frac{6.63\times10^{-34}(J.s)}{(4\times3.14)(9.109\times10^{-31}kg)\,(2\,m/s)}$

$\approx 3\times10^{-5}$ metres.

Conclusion : If we increase the accuracy in velocity then uncertainity in position increase and vice versa.

3. **(a) 2.64×10^{-30} m, (b) 30μm**

Sol. (a) $m = 1g = 10^{-3}$ kg

$v = 100$ cm/s $= 1$m/s.

$\Delta v = 0.02$ m/s. (from 0.99 to 1.01 m/s)

$\therefore \quad \Delta x = \frac{h}{4\pi m\Delta v} = \frac{6.63\times10^{-34}}{4\times3.14\times10^{-3}\times0.02}$

$\therefore \quad \Delta x = 2.64 \times 10^{-30}$ m **Ans.**

(b) $m_e = 9.1 \times 10^{-31}$ kg

$\Delta v = 2$ m/s (from 99 to 101 m/s)

$\Delta x = \frac{6.63\times10^{-34}}{4\times3.14\times9.1\times10^{-31}\times2}$

$= 30\mu m$ **Ans.**

The uncertainty in position of electron is significant as it is comparable to its dimensions. It is not the case for the macroscopic body.

4.
Sol.

According to De-broglie : $\lambda_e = \frac{h}{m_e v_n}$

Now for an electron to have a wave nature, and rotate in a circular orbit around nucleus, the circumference should be equal to a whole number multiple of the wavelength.

$\therefore \quad 2\pi r = n\lambda$

or $\quad \lambda = \frac{2\pi r}{n}$

$\therefore \quad \frac{h}{mv} = \frac{2\pi r}{n} \quad \Rightarrow mvr = \frac{nh}{2\pi}$

5. **1.325×10^{-19} cm s^{-1}**

Sol. We have,

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

or $\quad v = \frac{h}{m\lambda}$

$= \frac{6.626\times10^{-27}}{0.01\times10^{-3}\times0.05\times10^{-7}}$

$= 1.325\times10^{-19}$ cm s^{-1}

6. **4.70×10^{-10} m**

Sol. Energy required for ionization = 13.6 eV.

Energy given = (1.5 × 13.6) eV = 20.4 eV

$\therefore \quad$ K.E = 20.4 – 13.6 = 6.8 eV

$\therefore$

$\lambda = \frac{h}{\sqrt{2mE}} \Rightarrow \lambda = \frac{6.63\times10^{-34}}{\sqrt{2\times9.1\times10^{-31}\times6.8\times1.6\times10^{-19}}}$

= 4.71Å **Ans.**

7. **33 V**

Sol. $\lambda_{eff} = 0.05$ Å

$\therefore \quad p = \frac{h}{\lambda}$

or $\quad m_p v_p = \frac{h}{\lambda} \Rightarrow m_p v_p^2 = \left(\frac{h^2}{\lambda^2}\times\frac{1}{m_p}\right)$

or $\quad KE = \frac{h^2}{\lambda^2}\times\frac{1}{2m_p}$

This K.E. is provided by applying a voltage of 'V' volts which gives the proton energy = qV.

$\therefore \quad qV = \frac{h^2}{2m_p\lambda^2}$

$\therefore \quad V = \frac{h^2}{2m_p\lambda^2 q}$

$= \frac{(6.63\times10^{-34})^2}{2\times(1.67\times10^{-27})\times(0.05\times10^{-10})^2\times1.6\times10^{-19}}$

$\therefore$ V = 32.9 V **Ans.**

8. **18.6 kV**

Sol. $p=\frac{h}{\lambda}$

or $m_pv_p=\frac{h}{\lambda}\Rightarrow m_pv_p^2=\left(\frac{h^2}{\lambda^2}\times\frac{1}{m_p}\right)$

or $KE=\frac{h^2}{\lambda^2}\times\frac{1}{2m_p}$

This K.E. is provided by applying a voltage of 'V' volts which gives the proton energy = qV.

$\therefore$ $qV=\frac{h^2}{2m_p\lambda^2}$

$V=\frac{h^2}{2m_e\lambda^2 q}$

$=\frac{(6.63\times10^{-34})^2}{2\times(9.1\times10^{-31})\times(0.09\times10^{-10})^2\times(1.6\times10^{-19})}$

$\therefore$ voltage = 18.64×10^3 V

9. **0.123 Å**

Sol. V = 10 kv

We know that : $\lambda=\frac{h}{\sqrt{2meV.}}$

$\therefore$ $\lambda=\frac{6.63\times10^{-34}}{\sqrt{2\times9.1\times10^{-31}\times1.6\times10^{-19}\times10^4}}$

$\therefore$ λ = 0.123 Å **Ans.**

10. **4.53×10^{-10} m**

Sol. $v_e=1.6\times10^6$ m/s

$m_e=9.1\times10^{-31}$ kg

$\lambda=\frac{h}{m_ev_e}=\frac{6.6\times10^{-34}}{(9.1\times10^{-31})(1.6\times10^6)}$

$\lambda=4.53\times10^{-10}$ m

11. **3.31×10^{-10} m**

Sol. $v_e=2.19\times10^6$ m/s

$m_e=9.1\times10^{-31}$ kg

$\lambda=\frac{h}{m_ev_e}=\frac{6.6\times10^{-34}}{(9.1\times10^{-31})(2.19\times10^6)}$

$=3.31\times10^{-10}$ m

12. **(a)**

Sol. $\lambda=\frac{h}{mv}=\frac{6.6\times10^{-34}}{0.06\times10}$

$=1.1\times10^{-33}$ m

13. **(a)**

14. **(a)**

Sol. $\Delta x.\ m\ \Delta v=\frac{h}{4\pi}$

$\Delta v=\frac{h}{4\pi m\ \Delta x}$

$=\frac{6.6\times10^{-34}}{4\times3.14\times0.025\times10^{-5}}$

$=2.1\times10^{-28}$ m.

15. **(d)**

Sol. De-broglie wavelength is applicable for particles

16. **(d)**

Sol. $r\propto n^2$ for H-atom.

For $n_1=1$, $n_2=2$ ratio of radii = 1 : 4

$\Delta\epsilon=13.6\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)$ eV

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

= 10.2 eV

17. **(a)**

18. **(c)**

Sol. $\Delta p=10^{-5}$ kg m/s

$\Delta p\ .\ \Delta x=\frac{h}{4\pi}$

$\Delta x=\frac{h}{4\pi(\Delta p)}=\frac{6.6\times10^{-34}}{4\times3.14\times10^{-15}}$

$=5.25\times10^{-30}$ m.

19. **(c)**

Sol. $\lambda=\frac{h}{mv}$

$\frac{\lambda_1}{\lambda_2}=\frac{m_2}{m_1}=\frac{1.67\times10^{-27}}{9.1\times10^{-31}}$

$=1.8\times10^3$

20. **(a)**

Sol. $\lambda=\frac{h}{p}$

$2.2\times10^{-11}=\frac{6.6\times10^{-34}}{p}$

$p=3\times10^{-23}\,kg-ms^{-1}$