Worksheet Solution

(Chapter 1 Basic Nuclear Properties)

MCQ (Multiple Choice Questions)

Ans. 1: (b)

Solution: $b = \frac{2Ze^2}{4\pi \in_0 E}$

Ans. 2: (a)

Solution: $b = \frac{2Ze^2}{4\pi \in_0 E} = 2.275 \times 10^{-13} m$

Ans. 3: (d)

Ans. 4: (a)

Solution: $R = 1.2\, A^{1/3}$ fm

Ans. 5: (b)

Solution: $p = \frac{h}{\lambda} = \frac{6.6\times10^{-34}}{10^{-15}} = 6.6\times10^{-19} kgm/\text{sec}$ where $\lambda \approx R$

Ans. 6: (b)

Solution: $p_F(p) = \frac{\hbar}{r_0}\left(\frac{9\pi}{4}\right)^{1/3}\left(\frac{Z}{A}\right)^{1/3}$

Ans. 7: (d)

Solution: $E_F(p) = \frac{p_F^2}{2m_p} = \frac{(\hbar c)^2}{2R_0^2 m_p c^2}\left(\frac{9\pi}{4}\right)^{2/3}\left(\frac{Z}{A}\right)^{2/3}$

Ans. 8: (d)

Solution: $E_{total} = \frac{3}{10}\left(\frac{9\pi}{4}\right)^{2/3}\frac{\hbar^2 c^2}{mc^2 R_0^2}\left(\frac{Z^{5/3}+N^{5/3}}{A^{2/3}}\right)$

Ans. 9: (d)

Solution: Total energy of nucleus is given by $E_{total} = Z\langle E(p)\rangle + N\langle E(p)\rangle$ where Z is number of proton and $N = A - Z$ is number of neutrons

$$E_{total} = \frac{3}{10}\left(\frac{9\pi}{4}\right)^{2/3}\frac{\hbar^2 c^2}{mc^2 R_0^2}\left(\frac{Z^{5/3}+N^{5/3}}{A^{2/3}}\right)$$

The term dependent on N,Z and A is $\frac{Z^{5/3}+N^{5/3}}{A^{2/3}}=A\left(1+\frac{5}{9}\left(\frac{N-Z}{A}\right)^2\right)$

$$E_{total}=\frac{3}{10}\left(\frac{9\pi}{4}\right)^{2/3}\frac{\hbar^2c^2}{mc^2R_0^2}A+\frac{1}{6}\left(\frac{9\pi}{4}\right)^{2/3}\frac{\hbar^2c^2}{mc^2R_0^2}\left(\frac{N-Z}{A}\right)^2$$

$$E_{total}=\left(\frac{9\pi}{4}\right)^{2/3}\frac{\hbar^2c^2}{mc^2R_0^2}\left[\frac{3}{10}A+\frac{1}{6}\left(\frac{N-Z}{A}\right)^2\right]$$

NAT (Numerical Answer Type)

Ans. 10: 2.29

Solution: Mass of iron nucleus is $55.85u$ where $u=1.66\times10^{-27}kg$ the mass of iron nucleus is

$$55.8\times1.66\times10^{-27}kg=9.27\times10^{-26}kg$$

Volume $\frac{4\pi}{3}R^3$ where $R=R_0A^{1/3}$ where $R_0=1.2\times10^{-15}m$ and $A=56$

So volume is $\frac{4\pi}{3}\times(R_0)^3\left(A^{1/3}\right)^3=\frac{4\pi}{3}R_0^3A=\frac{4\times3.14}{3}\times\left(1.2\times10^{-15}\right)^3\times56=405\times10^{-45}m^3$ en

Density is $d=\frac{m}{V}=\frac{9.27\times10^{-26}}{405\times10^{-45}}=0.0228\times10^{19}=2.29\times10^{17}kg/m^3$

Ans. 11: 2.7

Solution: $R=R_0A^{1/3}=1.2\times(12)^{1/3}=2.7\,fermi$

Ans. 12: 86.86

Solution: $\frac{4\pi}{3}\times R^3=\frac{4\pi}{3}\times\left(R_0A^{1/3}\right)^3=\frac{4\pi}{3}\times R_0^3\times A=\frac{4\pi}{3}\times(1.2\,fermi)^3\times12$

$$=\frac{260}{3}(fermi)^3=86.86(fermi)^3$$

Ans. 13: 2.4

Solution: $\rho=\frac{m}{V}=\frac{m}{\left(\frac{4\pi}{3}\right)\times R^3}=\frac{(12u)}{\frac{4\pi}{3}\left(2.7\times10^{-15}m\right)^3}=2.4\times10^{17}kg/m^3$

Ans. 14: 2

Solution 4: $\frac{R_{Pb}}{R_{Mg}}=\frac{R_0A_{Pb}^{1/3}}{R_0A_{Mg}^{1/3}}=\left[\frac{208}{26}\right]^{1/3}=(8)^{1/3}=2$

Ans. 15: 3.6

Solution: $R_{Mg}=\left(\frac{A_{Mg}}{A_{Cu}}\right)^{1/3}R_{Cu}=\left(\frac{27}{64}\right)^{13}\times 4.8\times 10^{-13}=3.6\times 10^{-13}\,cm=3.6\times 10^{-15}\,m$

Ans. 16: 1.66

Solution: The radius of a nucleus can be combined as $\frac{\lambda}{2\pi}$ (greater than the wavelength of electron)

The moment $p=\frac{h}{\lambda}$

Ans. 17: 2.5 .

Solution: $\langle p\rangle=\frac{h}{\lambda}=\frac{h}{R}=\frac{h}{R_0(A)^{1/3}}=\frac{6.6\times 10^{-34}}{1.2\times 10^{-15}\times(12)^{1/3}}=\frac{6.6}{1.2\times 2.29}\times 10^{-19}=2.5\times 10^{-19}$

Ans. 18: 0.33

Solution: $p_F=\frac{\hbar}{r_0}\left(\frac{9\pi}{4}\right)^{1/3}\left(\frac{Z}{A}\right)^{1/3}\qquad p_F\propto Z^{1/3}\quad\Rightarrow p_F\propto Z^{0.33}$

Ans. 19: 0.66

Solution: $E_F=\frac{p_F^2}{2m_p}=\frac{(\hbar c)^2}{2R_0^2m_pc^2}\left(\frac{9\pi}{4}\right)^{2/3}\left(\frac{Z}{A}\right)^{2/3}\qquad ,E_F\propto Z^{2/3}\quad\Rightarrow E_F\propto Z^{0.66}$