Chapter 15. Structure of Atoms and Nuclei

MCQ'S (1 Mark Each)

1). When an electron jumps from higher energy orbit to lower energy orbit, the difference in the energies in the two orbits is radiated as quantum (photon) of….

(a) $E = mc^2$ (b) $E = \frac{h}{\upsilon}$ (c) $E = \frac{hc}{\lambda}$ (d) $E = \frac{\lambda}{hc}$

Ans : (c) $E = \frac{hc}{\lambda}$

2). The radii of Bohr orbit are directly proportional to….

(a) Principal quantum number

(b) Square of principal quantum number

(c) Cube of principal quantum number

(d) Independent of principal quantum number

Ans : (b) square of principal quantum number

3). According to Bohr second postulate, the angular momentum of electron is the integral multiple of $\frac{h}{2\pi}$. The S.I unit of Plank constant *h* is same as……

(a) Linear momentum (b) angular momentum (c) Energy (d) Centripetal force

Ans : (b) angular momentum

4). The ionization energy of Hydrogen atom in its ground state is……

(a) 3.4 e V (b) 10.2 eV (c) 13.6 eV (d) – 13.6 eV

Ans : (c) 13.6 eV

5). For hydrogen atom, the minimum excitation energy (of n =2) is….

(a) 3.4 e V (b) 10.2 eV (c) 13.6 eV (d) – 10.2 eV

Ans : (b) 10.2 eV

6). The dimensions of Rydberg's constant are…..

(a) $[M^0 L^1 T^0]$ (b) $[M^0 L^{-1} T^0]$ (c) $[M^0 L^1 T^1]$ (d) $[M^0 L^{-1} T^{-1}]$

Ans : (b) $[M^0 L^{-1} T^0]$

7). In a Hydrogen, electron jumps from fourth orbit to second orbit. The wave number of the radiations emitted by electron is

(a) $\frac{R}{16}$ (b) $\frac{3R}{16}$ (c) $\frac{5R}{16}$ (d) $\frac{7R}{16}$

Ans : (b) $\frac{3R}{16}$

8). The speed of electron having de Broglie wavelength of 10^{-10} m is

($m_e = 9.1 \times 10^{-31}$ kg, $h = 6.63 \times 10^{-34}$ J-s)

(a) 7.28×10^{6} m/s (b) 4×10^{6} m/s (c) 8×10^{5} m/s (d) 5.25×10^{5} m/s

Ans: (a) 7.28×10^{6} m/s

9). The decay constant λ of a certain radioactive material is 0.2166 per day. The average life τ of the radioactive material is….

(a) 5.332 days (b) 4.617days (c) 2.166 days (d) 1.083 days

Ans : (b) 4.617 days

10). The ratio of areas of the circular orbit of an electron in the ground state to that of first excited state of an electron in hydrogen atom is…

(a) 16 : 1 (b) 4 :1 (c) 1 :4 (d) 1 :16

Ans : (d) 1 :16

Very Short Answer (VSA) (1 MARK Each)

1. What is the angular momentum of an electron in first exited state for hydrogen atom?

2. If a_O is the Bohr radius and n is the principal quantum number then, state the relation for the radius of n^{th} orbit of electron in terms of Bohr radius and principal quantum number.

3. In which region of electromagnetic spectrum for Hydrogen, does the Lyman series lies?

4. How much energy must be supplied to hydrogen atom, to free (remove) the electron in the ground state?

5. State the value of minimum excitation energy for Hydrogen atom.

6. What is the energy of electron in hydrogen atom for $n = \infty$.

7. What is nuclear energy?

8. What is Radioactivity.

9. The radius of the smallest orbit of the electron (a_O) in hydrogen atom is 0.053 nm. What is the radius of the 4th orbit of the electron in hydrogen atom.

(Hint: $r_4 = a_O\, n^2 = 0.053 \times 16 = 0.848$ nm)

10. The half-life of a certain radioactive species is 6.93×10^5 seconds. What is the decay constant?

(Hint: $\lambda = \frac{0.693}{T_{1/2}} = 10^{-6}\, sec$)

11. The linear momentum of the particle is 6.63 kg m/s. Calculate the de Broglie wavelength.

(Hint: $\lambda = \frac{h}{p} = 10^{-34}\, m$)

Short Answer I (SA1) (2 MARKS Each)

1. Starting with $r = \frac{\epsilon_o h^2 n^2}{\pi m Z e^2}$, Show that the speed of electron in n^{th} orbit varies inversely to principal quantum number.

2. State Bohr second postulate for atomic model. Express it in its mathematical form.

3. State any two limitations of Bohr's model for hydrogen atom.

4. Using de Broglie's hypothesis, obtain the mathematical form of Bohr's second postulate.

5. Show that half-life period of radioactive material varies inversely to decay constant λ.

6. Define (i) Excitation energy (ii) Ionization energy

7. Define 1) atomic number 2) mass number.

8. What are isotopes? Give one example.

9. What are isotones? Give one example.

10. Define mass defect and state an expression for it.

11. What are the quantities conserved in a nuclear reaction?

12. Give one application of 1) nuclear fission 2) nuclear fusion.

13. Explain: Nuclear binding energy.

14. What is alpha decay? Give its expression.

15. Calculate the longest wavelength in Paschen series.

(Given $R_H = 1.097 \times 10^7\ m^{-1}$)

16. The angular momentum of electron in 3rd Bohr orbit of Hydrogen atom is 3.165×10^{-34} kg m^2 /s. Calculate Plank's constant *h*. ***(Ans: h= 6.63 × 10^{-34} Js)***

17. The half-life of a certain radioactive nucleus is 3.2 days. Calculate (i) decay constant (ii) average life of radioactive nucleus. ***(Ans: λ = 0.2166 per day, τ = 4.617 days)***

18. Draw a neat, labelled diagram showing energy levels and transition between them for hydrogen atom.

Short Answer II (SA2) (3 MARKS Each)

1) Derive an expression for the radius of the n^{th} Bohr orbit for hydrogen atom.
2) Using the expression for energy of electron in the n^{th} orbit, Show that

$$\frac{1}{\lambda} = R_H\left(\frac{1}{n^2} - \frac{1}{m^2}\right)$$, Where symbols have their usual meaning.

3) Show that for radioactive decay $N(t) = N_O e^{-\lambda t}$, where symbols have their usual meaning.
4) Obtain an expression for half life time of radioactive material. Hence state the relation between average life and half life time of radioactive material.
5) State three properties of alpha particles.
6) Calculate the wavelength for the first three lines in Paschen series. (Given $R_H = 1.097 \times 10^7\ m^{-1}$) ***(Ans: $\lambda_1 = 1.876 \times 10^{-6}$ m, $\lambda_2 = 1.282 \times 10^{-6}$ m, $\lambda_3 = 1.094 \times 10^{-6}$ m)***
7) Calculate the shortest wavelength in Paschen series if the longest wavelength in Balmar series is 6563 A°. ***(Ans: λ_B =6563 A, λ_p = 8203.75 A)***
8) A radioactive substance decays to (1/10)th of its original value in 56 days. Calculate its decay constant. ***(Ans: λ =4.112 ×10^{-2} per day)***

Long Answer (LA) (4 marks Each)

1) State the postulates of Bohr's atomic model. Hence show energy of electron varies inversely to the square of principal quantum number.

2) Obtain an expression for wavenumber, when electron jumps from higher energy orbit to lower energy orbit. Hence show that the shortest wavelength for Balmar series is $4/R_H$.
3) Obtain an expression for decay law of radioactivity. Hence show that the activity $A(t) = \lambda N_O e^{-\lambda t}$.
4) Using the expression for the radius of orbit for Hydrogen atom , show that the linear speed varies inversely to principal quantum number *n* the angular speed varies inversely to the cube of principal quantum number *n*.