CHAPTER - 02
STRUCTURE OF ATOM

1. 3 Atomic number = no.of protons

Mass number = no.of protons + no.of neutrons

$\therefore$ Nucleus contains 11 protons and 12 neutrons

2. 4

Particle	Charge	Mass (approx.)
e	–1	0 u
p	1	1u
n	0	1 u
α	2	4 u

$\therefore$ order of e/m ratio is n < α < p < e

3. 2 $E = \frac{hc}{\lambda}$ or $E \alpha \frac{1}{\lambda}$

Thus, $\frac{E_1}{E_2} = \frac{\lambda_2}{\lambda_1} = \frac{16000\ A^0}{8000\ A^0} = 2 \Rightarrow E_1 = 2E_2$

4. 3 Electrons are ejected when frequency of incident light crosses the threshold value (ν_0)

5. 2 Both assertion and reason are true but reason is not the correct explanation of assertion. The difference between the energies of adjacent energy levels decreases as we move away from the nucleus. Thus in H atom
$E_2 - E_1 > E_3 - E_2 > E_4 - E_3$.....

6. 3 $\frac{1}{\lambda_{min}} = R_H\left[\frac{1}{2^2} - \frac{1}{\infty^2}\right] = \frac{R_H}{4}$

$\frac{1}{\lambda_{mas}} = R_H\left[\frac{1}{2^2} - \frac{1}{3^2}\right] = \frac{5R_H}{36}$

Thus, $\frac{\lambda_{max}}{\lambda_{min}} = \frac{9}{5}$

7. 1 $n_{higher} = 11$ and $n_{lower} = 1$

Number of uv radiations = 10

Number of visible radiations = 9

Number of infrared radiations = Total radiations – (10 + 9) = $\frac{11\times10}{2} - 19 = 36$

Thus, Z – (x + y) = 36 – (10 + 9) = 17

8. 2 $r \alpha \frac{n^2}{Z}$; $\frac{r_{He^+}}{r_{Be^{3+}}} = \frac{2^2/2}{3^2/4} = \frac{8}{9} \Rightarrow r_{Be^{3+}} = \frac{9'b'}{8}$

9. 1 $2\pi r_n = n\lambda$ and $r_n = a_0\frac{n^2}{z}$

$\lambda = \frac{2\pi r_n}{n} = \frac{2\pi a_0 n}{z} = x\pi a_0$

Thus, $x = \frac{2}{3}$

10. 4 According to Heisenberg's principle, exact position and exact velocity of an electron cannot be determined simultaneously. Also, $\Delta x.\Delta p \geq \frac{h}{4\pi}$

11. 1 $\Delta p = m \times \Delta v$

$\Delta p = 9.1\times10^{-28}\times3.0\times10^{4}\times\frac{0.001}{100}$

$\Delta P = 2.73\times10^{-24}$

Hence $\Delta x = \frac{h}{\Delta p\times4\pi} = \frac{6.626\times10^{-27}}{2.73\times10^{-28}\times4\times3.14}$

$\Delta x = 1.92\,cm.$

12. 3 Number of radial nodes = n – ℓ – 1

Number of angular nodes = ℓ

Thus, number of radial nodes of 5s orbital = 5 – 0 –1 = 4

Number of angular nodes of $3d_{yz}$ orbital = 2

Total number of nodes of $4d_{xy}$ orbital = (4 – 2–1) + (2) = 3 and number of radial nodes of 3p orbital = 3 – 1 – 1 = 1

13. 3 In chromium 19th electron is present in 4s orbital

14. 1 'yz'-plane is a node for p_x orbital

15 4 Value of $|\psi|^2$ is maximum at r = 0, thus it is an 's' orbital. It has only one radial node, thus it is a '2s' orbital.

16. 1 Energy of a given orbital decreases with increase in the atomic number.

17. 2 Energy of incident light = $h\nu$ = $6.6 \times 10^{-34} \times 5.8 \times 10^{14} \times 6.24 \times 10^{18}$ = 2.38 eV.

Thus, metals Na and K only can give photocurrent with 2.38 eV photons

18. 54

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

For $Be^{3+} \Rightarrow Z = 4$

First excited state n = 2

$$E_n = \frac{-13.6 \times 4^2}{2^2} = -13.6 \times 4 = -54.4\,eV$$

19. 3 $n - \ell - 1 = 2$ and $\ell = 0 \Rightarrow n = 3$

20. 25 No.of orbitals in a shell = n^2

21. C

$$n_2 + n_1 = 4 \quad -①$$

$$n_2^2 - n_1^2 = 8 \quad -②$$

From eqn ②

$$(n_2 - n_1)(n_2 + n_1) = 8$$

$$n_2 - n_1 = \frac{8}{4} = 2 \quad -③$$

From ① and ③

$$2n_2 = 6$$

$$n_2 = 3$$

$$\therefore n_1 = 1$$

Transition is $n_2 = 3 \longrightarrow n_1 = 1$

$$\bar{\nu} = \frac{1}{\lambda} = R_H (2)^2 \left[\frac{1}{1^2} - \frac{1}{3^2}\right]$$

$$= 4R_H \left[1 - \frac{1}{9}\right]$$

$$= 4R_H \times \frac{8}{9}$$

$$\lambda = \frac{9}{32 R_H}$$

22.

$$R_3 = \frac{a_0 (3)^2}{3} = 3a_0 = x$$

$$a_0 = \frac{x}{3}$$

$$\lambda = \frac{2\pi R_1}{n} = \frac{2\pi\, a_0 (1)^2}{3 \times 1}$$

$$= \frac{2\pi a_0}{3} = \frac{2\pi x}{9}$$

23. C

$$E = \frac{hc}{\lambda} = \frac{2\times10^{-25}}{4000\times10^{-10}}\ J$$

$$= 0.5\times10^{-18}\ J$$

$$= 5\times10^{-19}\ J = 30.11\times10^{4}\ J\ mol^{-1}$$

$$= 301.1\ kJ\ mol^{-1}$$

$$BDE = 246.5\ kJ\ mol^{-1}$$

$$KE = E - BDE = 301.1 - 246.5 = 54.6\ kJ\ mol^{-1}$$

% Energy Converted into $KE = \frac{54.6}{301.1}$

$$= 18\%$$

24. C

$$E_1 = -E$$

$$KE = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2\,KE}{m}}$$

But $KE = h\nu - h\nu_0$

$$E_2 (4^{2+}) = \frac{-E(3)^2}{1} = -9E$$

$$\therefore \nu_0 = 9E$$

$$KE = E_p - 9E$$

$$\therefore v = \sqrt{\frac{2(E_p - 9E)}{m}}$$

25. A

$$KE_1 = x \qquad PE_1 = -2x$$

$$KE_2 = \frac{x}{4} \qquad PE_2 = \frac{-2\times x}{4} = \frac{-x}{2}$$

$$\Delta PE = \frac{-x}{2} - (-2x) = \frac{-x}{2} + 2x = \frac{3x}{2}$$

26. B

$mvr = \frac{nh}{2\pi} = 3.1652 \times 10^{-34}$

$n \times 1.05 \times 10^{-34} = 3.1652 \times 10^{-24}$

$n = 3$

$n_2 = 3 \longrightarrow n_1 = 2$

$\bar{\nu} = R_H (2)^2 \left[\frac{1}{2^2} - \frac{1}{3^2}\right]$

$= 4R_H \left[\frac{1}{4} - \frac{1}{9}\right] = 4R_H \times \frac{5}{36}$

$= \frac{5R_H}{9}$

27. B

$\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mKE}}$

$KE = h(\nu - \nu_0)$

$\therefore \lambda = \frac{h}{\sqrt{2mh(\nu - \nu_0)}}$

$\therefore \lambda \propto \frac{1}{(\nu - \nu_0)^{1/2}}$

28. ABC

$E = -\frac{Ze^2}{2R}$

At $R = a_0$

$E_1 = -\frac{Ze^2}{2a_0}$

At $R = 2a_0$

$E_2 = \frac{-Ze^2}{2(2a_0)} = -\frac{Ze^2}{4a_0}$

$E_2 > E_1$

29. AC

30. AD

$E_3 = E_1 + E_2$

$h\nu_3 = h\nu_1 + h\nu_2$

$\nu_3 = \nu_1 + \nu_2$

Also $\frac{hc}{\lambda_3} = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2}$

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

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

31. BC

$RE = \frac{a_0 n^2}{Z} \times -\frac{R_H Z^2}{n^2}$

$= -a_0 R_H Z$

$V_R = \frac{V_0 Z}{n} \times \frac{a_0 n^2}{Z}$

$= V_0 a_0 n$

$\therefore V_R \propto n$

$\frac{V}{E} = \frac{V_0 Z \times n^2}{n \times -R_H(Z^2)}$

$\frac{V}{E} \propto n$

$\frac{R}{E} = \frac{a_0 n^2 \times n^2}{Z \times -R_H Z^2}$

$\frac{R}{E} \propto n^4$

32. 3.00

$n \longrightarrow n=2$

$E_1 : \ 10.2 + 17.0 = 27.2\ eV = \frac{hc}{\lambda_1}$

$\frac{1}{\lambda_1} = R_H Z^2 \left[\frac{1}{2^2} - \frac{1}{n^2}\right]$

$\frac{27.2}{hc} = R_H Z^2 \left[\frac{1}{4} - \frac{1}{n^2}\right]$ — ①

$n \longrightarrow n=3$

$E_2 : \ 4.25 + 5.95 = 10.20\ eV : \frac{hc}{\lambda_2}$

$\frac{10.2}{hc} : \ R_H Z^2 \left[\frac{1}{9} - \frac{1}{n^2}\right]$ — ②

① / ② $\Rightarrow$ $\frac{27.2}{10.2} = \frac{\frac{1}{4} - \frac{1}{n^2}}{\frac{1}{9} - \frac{1}{n^2}}$

$\frac{27.2}{9} - \frac{27.2}{n^2} - \frac{10.2}{4} + \frac{10.2}{n^2} = 0$

$\frac{-17}{n^2} + \frac{17}{36} = 0$

$-\frac{1}{n^2} = -\frac{1}{36}$

$n = 6$

Sub $n=6$ in eqn ①

$\frac{27.2}{hc} = R_H (Z^2) \left[\frac{1}{2^2} - \frac{1}{6^2}\right]$

$27.2 = hc R_H (Z^2) \left[\frac{1}{4} - \frac{1}{36}\right]$

$27.2 = 13.6 (Z^2) \left[\frac{8}{36}\right]$

$Z^2 = \frac{27.2}{13.6} \times \frac{36}{8} = \frac{2 \times 36}{8 \cdot 4} = 9$

$Z = \underline{\underline{3}}$

33. 2.00

At r_0,

$$\psi_{2s}^2 = \left[\frac{1}{4\sqrt{2\pi}}\left(\frac{1}{a_0}\right)^{3/2}\left(2-\frac{r_0}{a_0}\right)e^{-\frac{r_0}{a_0}}\right]^2 = 0$$

$$\Rightarrow \left(2-\frac{r_0}{a_0}\right)^2 = 0$$

$$2 = \frac{r_0}{a_0}$$

34. B

35. C