Structure of Atom

1. Incorrect set of quantum numbers from the following is: **(2023)**
   (a) n = 4, l = 3, m_l = −3, −2, −1, 0, +1, +2, +3, m_s = −1/2
   (b) n = 5, l = 2, m_l = −2, −1, +1, +2, m_s = +1/2
   (c) n = 4, l = 2, m_l = −2, −1, 0, +1, +2, m_s = −1/2
   (d) n = 5, l = 3, m_l = −3, −2, −1, 0, +1, +2, +3, m_s = +1/2

2. Given below are two statements:
   Statement I: The value of wave function, ψ depends upon the coordinates of the electron in the atom.
   Statement II: The probability of finding an electron at a point within an atom is proportional to the orbital wave function.
   In the light of the above statements, choose the correct answer from the option given below: **(2023)**
   (a) Statement I is true but Statement II is false.
   (b) Statement II is false but Statement II is true.
   (c) Both Statement I and Statement II are true.
   (d) Both Statement I and Statement II are false.

3. Select the correct Statements from the following:
   A. Atoms of all elements are composed of two fundamental particles.
   B. The mass of the electron is 9.10939×10^{-31} kg.
   C. All the isotopes of a given elements show same chemical properties.
   D. Protons and electrons are collectively known as nucleons.
   E. Dalton's atomic theory, regarded the atom as an ultimate particle of matter.
   Choose the correct answer from the option given below. **(2023)**
   (a) C, D and E only
   (b) A and E only
   (c) B, C and E only
   (d) A, B and C only

4. The relation between n_m, (n_m = the number of permissible values of magnetic quantum number (m)) for a given value of azimuthal quantum number (l) is **(2023)**
   (a) $l = 2n_m + 1$
   (b) $n_m = 2l^2 + 1$
   (c) $n_m = l + 2$
   (d) $l = \frac{n_m - 1}{2}$

5. Match List I with List II:

List I (quantum number)		List II (orbital)	
(A)	n = 2, l = 1	(i)	2s
(B)	n = 3, l = 2	(ii)	3s
(C)	n = 3, l = 0	(iii)	2p
(D)	n = 2, l = 0	(iv)	3d

   Choose the correct answer from the options given below: **(2022)**
   (a) A-iii, B-iv, C-ii, D-i
   (b) A-iii, B-iv, C-i, D-ii
   (c) A-iv, B-iii, C-i, D-ii
   (d) A-iv, B-iii, C-ii, D-i

6. When electromagnetic radiation of wavelength 300 nm falls on the surface of a metal, electrons are emitted with the kinetic energy of 1.68×10^5 J mol^{-1}. What is the minimum energy needed to remove an electron from the metal? **(2022)**
   (h = 6.626×10^{-34} Js, c = 3×10^8 ms^{-1}, N_A = 6.022×10^{23} mol^{-1})
   (a) 2.31×10^5 J mol^{-1}
   (b) 2.31×10^6 J mol^{-1}
   (c) 3.84×10^4 J mol^{-1}
   (d) 3.84×10^{-19} J mol^{-1}

7. Identify the incorrect statement from the following. **(2022)**
   (a) All the five 5d orbitals are different in size when compared to the respective 4d orbitals.
   (b) All the five 4d orbitals have shapes similar to the respective 3d orbitals.
   (c) In an atom, all the five 3d orbitals are equal in energy in free state.

(d) The shapes of d_{xy}, d_{yz} and d_{zx} orbitals are similar to each other and $d_{x^2-y^2}$ and d_{z^2} are similar to each other.

8. If radius of second Bohr orbit of the He^+ ion is 105.8 pm, what is the radius of third Bohr orbit of Li^{2+} ion? **(2022)**
   (a) 158.7 pm
   (b) 15.87 pm
   (c) 1.587 pm
   (d) 158.7 Å

9. A particular station of All India Radio, New Delhi, broadcasts on a frequency of 1,368 kHz (kilohertz). The wavelength of the electromagnetic radiation emitted by the transmitter is :
   [speed of light, c = 3.0×10^8 ms^{-1}] **(2021)**
   (a) 219.2 m
   (b) 2192 m
   (c) 21.92 m
   (d) 219.3 m

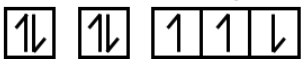
10. The number of protons, neutrons and electrons in $^{175}_{71}Lu$, respectively, are : **(2020)**
   (a) 104, 71 ad 71
   (b) 71, 71 and 104
   (c) 175, 104 and 71
   (d) 71, 104 and 71

11. The number of angular nodes and radial nodes in 3s orbital are **(2020 Covid Re-NEET)**
   (a) 1 and 0, respectively
   (b) 3 and 0, respectively
   (c) 0 and 1, respectively
   (d) 0 and 2, respectively

12. 4d, 5p, 5f and 6p orbitals are arranged in the order of decreasing energy. The correct option is **(2019)**
   (a) 5f > 6p > 5p > 4d
   (b) 6p > 5f > 5p > 4d
   (c) 6p > 5f > 4d > 5p
   (d) 5f > 6p > 4d > 5p

13. Which of the following series of transitions in the spectrum of hydrogen atom fall in visible region? **(2019)**
   (a) Lyman series
   (b) Balmer series
   (c) Paschen series
   (d) bracket series

14. Magnesium reacts with an element (X) to form an ionic compoun(d). If the ground state electronic configuration of (X) is $1s^2$ $2s^2$ $2p^3$, the simplest formula for this compound is **(2018)**
   (a) Mg_2X_3
   (b) MgX_2
   (c) Mg_3X_2
   (d) Mg_2X

15. Which one is a wrong statement? **(2018)**
   (a) Total orbital angular momentum of electron in 's' orbital is equal to zero
   (b) An orbital is designated by three quantum numbers while an electron in an atom is designated by four quantum numbers
   (c) The value of m for d_z^2 is zero
   (d) The electronic configuration of N atom is
   $1s^2$ $2s^2$ $2p_x^1$ $2p_y^1$ $2p_z^1$
   

16. Which one is the wrong statement? **(2017-Delhi)**
   (a) The energy of 2s orbital is less than the energy of 2p orbital in case of hydrogen like atoms
   (b) de-Broglie's wavelength is given by $\lambda = \frac{h}{mv}$, where m = mass of the particle, v = group velocity of the particle
   (c) The uncertainty principle is $\Delta E \times \Delta t \geq \frac{h}{4\pi}$
   (d) Half-filled and fully filled orbitals have greater stability due to greater exchange energy, greater symmetry and more balanced arrangement

17. The total number of orbitals present for principal quantum number, n = 4 is : **(2017-Gujarat)**
   (a) 30
   (b) 12
   (c) 15
   (d) 16

18. Which of the following pairs of d-orbitals will have electron density along the axes? **(2016-II)**
   (a) $d_{z^2}, d_{x^2-y^2}$
   (b) $d_{xy}, d_{x^2-y^2}$
   (c) d_{z^2}, d_{xz}
   (d) d_{xz}, d_{yz}

19. How many electrons can fit in the orbital for which : n = 3 and l = 1? **(2016-II)**
   (a) 10

(b) 14
(c) 2
(d) 6

20. Two electrons occupying the same orbital are distinguished by : **(2016-I)**
(a) Spin quantum number
(b) Principal quantum number
(c) Magnetic quantum number
(d) Azimuthal quantum number

21. Which is the correct order of increasing energy of the listed orbitals in the atom of titanium? (Atomic number Z = 22) **(2015 Re)**
(a) 3s 3p 4s 3d
(b) 3s 4s 3p 3d
(c) 4s 3s 3p 3d
(d) 3s 3p 3d 4s

22. The angular momentum of electron in 'd' orbital is equal to : **(2015)**
(a) $2\sqrt{3}h$
(b) $0h$
(c) $\sqrt{6}h$
(d) $\sqrt{2}h$

23. What is the maximum number of orbitals that can be identified with the following quantum numbers: **(2014)**
(a) 2
(b) 3
(c) 4
(d) 1

24. Calculate the energy in joule corresponding to light of wavelength 45 nm (Planck's constant h = 6.63 × 10^{-34} Js; speed of light c = 3 × 10^{8} ms^{-1}) **(2014)**
(a) 6.67 × 10^{11}
(b) 4.42 × 10^{-15}
(c) 4.42 × 10^{-18}
(d) 6.67 × 10^{15}

25. What is the maximum number of electrons that can be associated with the following set of quantum numbers? (n = 3, l = 1 and m = −1). **(2013)**
(a) 10
(b) 6
(c) 4
(d) 2

26. The value of Planck's constant is 6.63 × 10^{-34} Js. The speed of light is $3 \times 10^{8} ms^{-1}$. Which value is closest to the wavelength in nanometer of a quantum of light with frequency of $6 \times 10^{15} s^{-1}$? **(2013)**
(a) 10 nm
(b) 25 nm
(c) 50 nm
(d) 75 nm

27. Based on equation, $E = -2.178 \times 10^{-18} J \left(\frac{Z^2}{n^2}\right)$ certain conclusions are written. Which of them is not correct? **(2013)**
(a) The negative sign in equation simply means that the energy of electron bound to the nucleus is lower than it would be if the electrons were at the infinite distance from the nucleus.
(b) Larger the value of n, the larger is the orbit radius.
(c) Equation can be used to calculate the change in energy when the electron changes orbit.
(d) For n = 1, the electron has a more negative energy than it does for n = 6 which means that the electron is more loosely bound in the smallest allowed orbit.

Answer Key

S1. Ans. (b)

S2. Ans. (a)

S3. Ans. (c)

S4. Ans. (d)

S5. Ans. (a)

S6. Ans. (a)

S7. Ans. (d)

S8. Ans. (a)

S9. Ans. (d)

S10. Ans. (d)

S11. Ans. (d)

S12. Ans. (a)

S13. Ans. (b)

S14. Ans. (c)

S15. Ans. (d)

S16. Ans. (a)

S17. Ans. (d)

S18. Ans. (a)

S19. Ans. (c)

S20. Ans. (a)

S21. Ans. (a)

S22. Ans. (c)

S23. Ans. (d)

S24. Ans. (c)

S25. Ans. (d)

S26. Ans. (c)

S27. Ans. (d)

Solutions

S1. Ans.(b)

n = 5, l = 2, m = −2, −1, +1, +2, m_s = +1/2

S2. Ans.(a)

Statement I is true and Statement II is false.

S3. Ans.(c)

It is statement based question.

Statements B, C and E are correct.

(B) Mass of the electron is 9.10939 × 10^{-31} kg

(C) All the isotopes of given elements show same chemical properties.

(E) Dalton's atomic theory, regarded the atom as an ultimate particle of matter.

S4. Ans.(d)

Sol. Number of permissible values of magnetic quantum number for a given value of azimuthal quantum (l)

$\Rightarrow n_m = 2l + 1$

$\Rightarrow l = \frac{n_m - 1}{2}$

S5. Ans.(a)

n	l	Subshell notation
2	0	2s
2	1	2p
3	0	3s
3	1	3p
3	2	3d

S6. Ans.(a)

Energy of one photon = $\frac{hc}{\lambda}$ (λ = 300 nm)

For one mole photons, E = $\frac{hc}{\lambda} \times N_A$

E = $\frac{6.626\times10^{-34}\times3\times10^{8}\times6.023\times10^{23}}{300\times10^{-9}}$

E = 3.99 × 10^5 J mol^{-1}

Kinetic energy = 1.68 × 10^5 J mol^{-1}

W_0 = E – K.E.

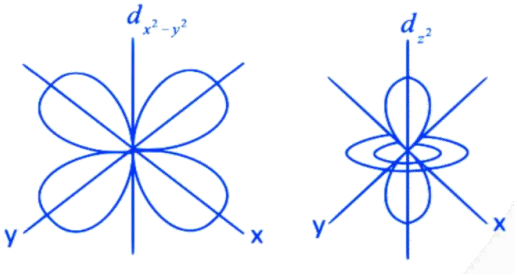
= 3.99 × 10^5 – 1.68 × 10^5

= 2.31 × 10^5 J mol^{-1}

S7. Ans.(d)

In an atom, all the five 3d orbitals are equal in energy in free state i.e., degenerate.

The shape of $d_{x^2-y^2}$ is different then shape of d_{z^2}.



The size of orbital depends on principal quantum number 'n' therefore all the five 3d orbitals are different in size when compared to the respective 4d orbitals.

Shape of orbitals depends on azimuthal quantum number 'l' therefore shapes of 4d orbitals are similar to the respective 3d orbitals.

S8. Ans.(a)

$r_n \propto n^2/Z$

$\frac{r_3(Li^{2+})}{r_2(He^{+})} = \frac{(n_3)^2}{Z(Li^{2+})} \times \frac{Z(He^{+})}{(n_2)^2}$

$\frac{r_3(Li^{2+})}{105.8} = \frac{(3)^2}{3} \times \frac{2}{(2)^2}$

= 105.8 × 3/2

$r_3(Li^{2+})$ = 158.7 pm

S9. Ans.(d)

$\lambda = \frac{c}{v}$

$\lambda = \frac{3\times10^8}{1368\times10^3} = 219.298\,m = 219.3\,m$

S10. Ans.(d)

$^{17}_{71}Lu$

Z = atomic number

Z = No. of Protons = 71 = No. of Electrons

No. of Neutrons = Mass no. – No. of Protons

= 175 – 71

=104

S11. Ans.(d)

Number of radial nodes = n – l – 1

Number of angular nodes = l

For 3s orbital,

l = 0

– Number of radial nodes = 3 – 0 – 1 = 2

– Number of angular nodes = 0

S12. Ans.(a)

n l

(n + 1) value for, 4d = 4 + 2 = 6

5p = 5 + 1 = 6

5f = 5 + 3 = 8

6p = 6 + 1 = 7

Lower value of (n + l) signifies lower energy

In case of 4d and 5p, lower value of n in 4d has compare to 5p.

So, 4d has less energy in comparison to 5p.

∴ Correct order of energy will be 5f > 6p > 5p > 4d

S13. Ans.(b)

In visible region Balmer series transitions fall in H-spectrum.

S14. Ans.(c)

Element (X) electronic configuration

$1s^2\ 2s^2\ 2p^3$

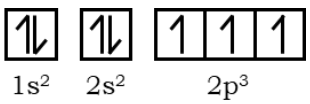
So, valency of X will be 3.

Valency of Mg is 2.

Formula of compound formed by Mg and X will be Mg_3X_2.

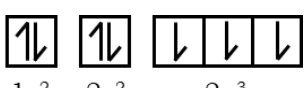
S15. Ans.(d)

According to Hund's Rule of maximum multiplicity, the correct electronic configuration of N-atom is



$1s^2$ $2s^2$ $2p^3$

Or



$1s^2$ $2s^2$ $2p^3$

∵ Option (d) violates Hund's Rule.

S16. Ans.(a)

The energy of 2s orbital is less than the energy of 2p orbital in case of hydrogen like atoms is a wrong statement because

1s > 2s = 2p > 3s = 3p = 3d ….. etc.

S17. Ans.(d)

The total number of orbital present in n = 4 is n^2.

$= (4)^2 = 16$

Shell	No. of orbital
s	1
p	3
d	5
f	7

S18. Ans.(a)

Among d-orbitals d_{z^2} and $d_{x^2-y^2}$ have their electron densities oriented towards axes.

S19. Ans.(c)

When n = 3 and l = 1 orbital is 3p, so total number of electron that can be filled are 6 but in any orbital only 2 electron can accumulate.

S20. Ans.(a)

2 electron occupying the same orbital can be distinguished using their spin quantum number (m_s) where one is clockwise (↑) and other is anti-clockwise (↓). In such case, the value of spin quantum number changes rest all quantum number remains the same.

S21. Ans.(a)

According to Aufbau's rule of increasing order of energy for filling up of electron.

3s < 3p < 4s < 3d

S22. Ans.(c)

Angular momentum= $\sqrt{l(l+1)}\frac{h}{2\pi}$

For d orbital l = 2

So, angular momentum= $\sqrt{2(2+1)}\frac{h}{2\pi}$

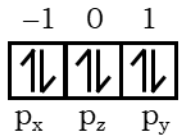
$$= \sqrt{6}\frac{h}{2\pi}$$

$\frac{h}{2\pi} = \hbar \rightarrow$ called as Planck's reducing constant or Dirac constant.

S23. Ans.(d)

n =3 l = 1 m_l = 0

l = p 3p = 1 orbital as m_l = 0 sp $3p_z$.



Thus, maximum no. of orbitals identified in $3p_z$ is 1.

S24. Ans.(c)

$E = \frac{hc}{\lambda}$

$E = \frac{6.63\times10^{-34}\times3\times10^{8}}{45\times10^{-9}} = 4.42 \times 10^{-18} J$

S25. Ans.(d)

n = 3 l = 1 m_l = −1

for p orbital l = 1

So orbital must be $3p_x$ or $3p_y$, where number of electron in each orbital will be 2.

S26. Ans.(c)

According to formula :

$E = \frac{hc}{\lambda}$ or hv

Where, $\frac{c}{\lambda} = v \Rightarrow \lambda = \frac{3\times10^{8}}{6\times10^{15}} = 50\ nm$

S27. Ans.(d)

The orbitals which are closer to nucleus are more strongly affected by the positive charged field of protons in nucleus. Whereas when we move away from nucleus and n (principal quantum number) increases, the effective influence of positive charged field decreases & electron in later (n) orbitals become loosely bounded.