CHAPTER 2

Structure of Atom

2.2 Atomic Models

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

2. Be^{2+} is isoelectronic with which of the following ions?
(a) H^+ (b) Li^+
(c) Na^+ (d) Mg^{2+} *(2014)*

3. Isoelectronic species are
(a) CO, CN^-, NO^+, C_2^{2-}
(b) CO^-, CN, NO, C_2^-
(c) CO^+, CN^+, NO^-, C_2
(d) CO, CN, NO, C_2 *(2000)*

4. The ion that is isoelectronic with CO is
(a) CN^- (b) N_2^+
(c) O^{2-} (d) N_2^- *(1997)*

5. Which one of the following is not isoelectronic with O^{2-}?
(a) Tl^+ (b) Na^+
(c) N^{3-} (d) F^- *(1994)*

2.3 Developments Leading to the Bohr's Model of Atom

6. Which of the following series of transitions in the spectrum of hydrogen atom falls in visible region?
(a) Brackett series (b) Lyman series
(c) Balmer series (d) Paschen series
(NEET 2019)

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

8. The value of Planck's constant is 6.63×10^{-34} Js. The speed of light is 3×10^{17} nm s^{-1}. Which value is closest to the wavelength in nanometer of a quantum of light with frequency of 6×10^{15} s^{-1}?
(a) 50 (b) 75
(c) 10 (d) 25 *(NEET 2013)*

9. According to law of photochemical equivalence the energy absorbed (in ergs/mole) is given as
($h = 6.62 \times 10^{-27}$ ergs, $c = 3 \times 10^{10}$ cm s^{-1}, $N_A = 6.02 \times 10^{23}$ mol^{-1})
(a) $\frac{1.196 \times 10^8}{\lambda}$ (b) $\frac{2.859 \times 10^5}{\lambda}$
(c) $\frac{2.859 \times 10^{16}}{\lambda}$ (d) $\frac{1.196 \times 10^{16}}{\lambda}$
(Karnataka NEET 2013)

10. The energies E_1 and E_2 of two radiations are 25 eV and 50 eV respectively. The relation between their wavelengths *i.e.*, λ_1 and λ_2 will be
(a) $\lambda_1 = \lambda_2$ (b) $\lambda_1 = 2\lambda_2$
(c) $\lambda_1 = 4\lambda_2$ (d) $\lambda_1 = \frac{1}{2}\lambda_2$ *(2011)*

11. The value of Planck's constant is 6.63×10^{-34} J s. The velocity of light is 3.0×10^8 m s^{-1}. Which value is closest to the wavelength in nanometers of a quantum of light with frequency of 8×10^{15} s^{-1}?
(a) 2×10^{-25} (b) 5×10^{-18}
(c) 4×10^1 (d) 3×10^7 *(2003)*

12. For given energy, $E = 3.03 \times 10^{-19}$ joules corresponding wavelength is
($h = 6.626 \times 10^{-34}$ J sec, $c = 3 \times 10^8$ m/sec)
(a) 65.6 nm (b) 6.56 nm
(c) 3.4 nm (d) 656 nm *(2000)*

13. What will be the longest wavelength line in Balmer series of spectrum?
(a) 546 nm (b) 656 nm
(c) 566 nm (d) 556 nm *(1996)*

2.4 Bohr's Model for Hydrogen Atom

14. Based on equation $E = -2.178 \times 10^{-18}\ \text{J}\left(\frac{Z^2}{n^2}\right)$, certain conclusions are written. Which of them is not correct?
    (a) Equation can be used to calculate the change in energy when the electron changes orbit.
    (b) 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.
    (c) 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.
    (d) Larger the value of n, the larger is the orbit radius. *(NEET 2013)*

15. According to the Bohr theory, which of the following transitions in the hydrogen atom will give rise to the least energetic photon?
    (a) $n = 6$ to $n = 1$ (b) $n = 5$ to $n = 4$
    (c) $n = 6$ to $n = 5$ (d) $n = 5$ to $n = 3$ *(Mains 2011)*

16. The energy of second Bohr orbit of the hydrogen atom is -328 kJ mol^{-1}; hence the energy of fourth Bohr orbit would be
    (a) -41 kJ mol^{-1} (b) -82 kJ mol^{-1}
    (c) -164 kJ mol^{-1} (d) -1312 kJ mol^{-1} *(2005)*

17. The frequency of radiation emitted when the electron falls from $n = 4$ to $n = 1$ in a hydrogen atom will be (Given ionization energy of H $= 2.18 \times 10^{-18}$ J atom^{-1} and $h = 6.626 \times 10^{-34}$ J s)
    (a) 1.54×10^{15} s^{-1} (b) 1.03×10^{15} s^{-1}
    (c) 3.08×10^{15} s^{-1} (d) 2.00×10^{15} s^{-1} *(2004)*

18. In hydrogen atom, energy of first excited state is -3.4 eV. Then find out *K.E.* of same orbit of hydrogen atom.
    (a) +3.4 eV (b) +6.8 eV
    (c) -13.6 eV (d) +13.6 eV *(2002)*

19. Who modified Bohr's theory by introducing elliptical orbits for electron path?
    (a) Rutherford (b) Thomson
    (c) Hund (d) Sommerfeld *(1999)*

20. The Bohr orbit radius for the hydrogen atom ($n = 1$) is approximately 0.530 Å. The radius for the first excited state ($n = 2$) orbit is (in Å)
    (a) 4.77 (b) 1.06
    (c) 0.13 (d) 2.12 *(1998)*

21. In a Bohr's model of an atom, when an electron jumps from $n = 1$ to $n = 3$, how much energy will be emitted or absorbed?
    (a) 2.389×10^{-12} ergs (b) 0.239×10^{-10} ergs
    (c) 2.15×10^{-11} ergs (d) 0.1936×10^{-10} ergs *(1996)*

22. The radius of hydrogen atom in the ground state is 0.53 Å. The radius of Li^{2+} ion (atomic number = 3) in a similar state is
    (a) 0.53 Å (b) 1.06 Å
    (c) 0.17 Å (d) 0.265 Å *(1995)*

23. The energy of an electron in the n^{th} Bohr orbit of hydrogen atom is
    (a) $\frac{13.6}{n^4}$ eV (b) $\frac{13.6}{n^3}$ eV
    (c) $\frac{13.6}{n^2}$ eV (d) $\frac{13.6}{n}$ eV *(1992)*

24. The spectrum of He is expected to be similar to that
    (a) H (b) Li^+
    (c) Na (d) He^+ *(1988)*

25. If r is the radius of the first orbit, the radius of n^{th} orbit of H-atom is given by
    (a) rn^2 (b) rn
    (c) r/n (d) r^2n^2 *(1988)*

2.5 Towards Quantum Mechanical Model of the Atom

26. In hydrogen atom, the de Broglie wavelength of an electron in the second Bohr orbit is [Given that Bohr radius, $a_0 = 52.9$ pm]
    (a) 211.6 pm (b) 211.6 π pm
    (c) 52.9 π pm (d) 105.8 pm *(Odisha NEET 2019)*

27. A 0.66 kg ball is moving with a speed of 100 m/s. The associated wavelength will be ($h = 6.6 \times 10^{-34}$ J s)
    (a) 6.6×10^{-32} m (b) 6.6×10^{-34} m
    (c) 1.0×10^{-35} m (d) 1.0×10^{-32} m *(Mains 2010)*

28. If uncertainty in position and momentum are equal, then uncertainty in velocity is
    (a) $\frac{1}{m}\sqrt{\frac{h}{\pi}}$ (b) $\sqrt{\frac{h}{\pi}}$ (c) $\frac{1}{2m}\sqrt{\frac{h}{\pi}}$ (d) $\sqrt{\frac{h}{2\pi}}$ *(2008)*

29. The measurement of the electron position is associated with an uncertainty in momentum, which is equal to 1×10^{-18} g cm s^{-1}. The uncertainty in electron velocity is (mass of an electron is 9×10^{-28} g)

(a) 1×10^5 cm s^{-1} (b) 1×10^{11} cm s^{-1}
(c) 1×10^9 cm s^{-1} (d) 1×10^6 cm s^{-1} *(2008)*

30. Given : The mass of electron is 9.11×10^{-31} kg, Planck constant is 6.626×10^{-34} J s, the uncertainty involved in the measurement of velocity within a distance of 0.1 Å is
(a) 5.79×10^5 m s^{-1} (b) 5.79×10^6 m s^{-1}
(c) 5.79×10^7 m s^{-1} (d) 5.79×10^8 m s^{-1}
(2006)

31. The uncertainty in momentum of an electron is 1×10^{-5} kg m/s. The uncertainty in its position will be ($h = 6.62 \times 10^{-34}$ kg m^2/s)
(a) 5.27×10^{-30} m (b) 1.05×10^{-26} m
(c) 1.05×10^{-28} m (d) 5.25×10^{-28} m *(1999)*

32. The de Broglie wavelength of a particle with mass 1 g and velocity 100 m/s is
(a) 6.63×10^{-35} m (b) 6.63×10^{-34} m
(c) 6.63×10^{-33} m (d) 6.65×10^{-35} m *(1999)*

33. The position of both, an electron and a helium atom is known within 1.0 nm. Further the momentum of the electron is known within 5.0×10^{-26} kg m s^{-1}. The minimum uncertainty in the measurement of the momentum of the helium atom is
(a) 8.0×10^{-26} kg m s^{-1} (b) 80 kg m s^{-1}
(c) 50 kg m s^{-1} (d) 5.0×10^{-26} kg m s^{-1}
(1998)

34. Uncertainty in position of an electron (Mass $= 9.1 \times 10^{-28}$ g) moving with a velocity of 3×10^4 cm/s accurate upto 0.001% will be
(Use $h/(4\pi)$ in uncertainty expression where $h = 6.626 \times 10^{-27}$ erg second)
(a) 5.76 cm (b) 7.68 cm
(c) 1.93 cm (d) 3.84 cm *(1995)*

35. Which of the following statements do not form a part of Bohr's model of hydrogen atom?
(a) Energy of the electrons in the orbits are quantized.
(b) The electron in the orbit nearest the nucleus has the lowest energy.
(c) Electrons revolve in different orbits around the nucleus.
(d) The position and velocity of the electrons in the orbit cannot be determined simultaneously.
(1989)

2.6 Quantum Mechanical Model of Atom

36. 4*d*, 5*p*, 5*f* and 6*p* orbitals are arranged in the order of decreasing energy. The correct option is
(a) $5f > 6p > 4d > 5p$ (b) $5f > 6p > 5p > 4d$
(c) $6p > 5f > 5p > 4d$ (d) $6p > 5f > 4d > 5p$
(NEET 2019)

37. Orbital having 3 angular nodes and 3 total nodes is
(a) 5*p* (b) 3*d* (c) 4*f* (d) 6*d*
(Odisha NEET 2019)

38. Which one is a wrong statement?
(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 electronic configuration of N atom is $1s^2\,2s^2\,2p_x^1\,2p_y^1\,2p_z^1$

1s	2s	$2p_x$	$2p_y$	$2p_z$
↑↓	↑↓	↑	↑	↓

(d) The value of *m* for d_{z^2} is zero. *(NEET 2018)*

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

40. How many electrons can fit in the orbital for which $n = 3$ and $l = 1$?
(a) 2 (b) 6
(c) 10 (d) 14 *(NEET-II 2016)*

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

42. Two electrons occupying the same orbital are distinguished by
(a) azimuthal quantum number
(b) spin quantum number
(c) principal quantum number
(d) magnetic quantum number. *(NEET-I 2016)*

43. Which is the correct order of increasing energy of the listed orbitals in the atom of titanium?
(At. no. $Z = 22$)
(a) 4*s* 3*s* 3*p* 3*d* (b) 3*s* 3*p* 3*d* 4*s*
(c) 3*s* 3*p* 4*s* 3*d* (d) 3*s* 4*s* 3*p* 3*d* *(2015)*

44. The number of *d*-electrons in Fe^{2+} ($Z = 26$) is not equal to the number of electrons in which one of the following?
(a) *d*-electrons in Fe ($Z = 26$)
(b) *p*-electrons in Ne ($Z = 10$)

(c) s-electrons in Mg (Z = 12)
(d) p-electrons in Cl (Z = 17) *(2015, Cancelled)*

45. The angular momentum of electron in 'd' orbital is equal to
(a) $2\sqrt{3}\hbar$ (b) $0\hbar$ (c) $6\hbar$ (d) $\sqrt{2}\hbar$
(2015, Cancelled)

46. What is the maximum number of orbitals that can be identified with the following quantum numbers?
$n = 3, l = 1, m_l = 0$
(a) 1 (b) 2
(c) 3 (d) 4 *(2014)*

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

48. The outer electronic configuration of Gd (At. No. 64) is
(a) $4f^5 5d^4 6s^1$ (b) $4f^7 5d^1 6s^2$
(c) $4f^3 5d^5 6s^2$ (d) $4f^4 5d^5 6s^1$
(Karnataka NEET 2013)

49. Maximum number of electrons in a subshell with $l = 3$ and $n = 4$ is
(a) 14 (b) 16
(c) 10 (d) 12 *(2012)*

50. The correct set of four quantum numbers for the valence electron of rubidium atom ($Z = 37$) is
(a) 5, 1, 1, +1/2 (b) 6, 0, 0, +1/2
(c) 5, 0, 0, +1/2 (d) 5, 1, 0, +1/2 *(2012)*

51. The orbital angular momentum of a p-electron is given as
(a) $\frac{h}{\sqrt{2}\,\pi}$ *(b)* $\sqrt{3}\,\frac{h}{2\pi}$
(c) $\sqrt{\frac{3}{2}}\,\frac{h}{\pi}$ (d) $\sqrt{6}\,\frac{h}{2\pi}$ *(Mains 2012)*

52. The total number of atomic orbitals in fourth energy level of an atom is
(a) 8 (b) 16
(c) 32 (d) 4 *(2011)*

53. If $n = 6$, the correct sequence for filling of electrons will be
(a) $ns \rightarrow (n-2)f \rightarrow (n-1)d \rightarrow np$
(b) $ns \rightarrow (n-1)d \rightarrow (n-2)f \rightarrow np$
(c) $ns \rightarrow (n-2)f \rightarrow np \rightarrow (n-1)d$
(d) $ns \rightarrow np \rightarrow (n-1)d \rightarrow (n-2)f$ *(2011)*

54. Maximum number of electrons in a subshell of an atom is determined by the following
(a) $2l + 1$ (b) $4l - 2$
(c) $2n^2$ (d) $4l + 2$ *(2009)*

55. Which of the following is not permissible arrangement of electrons in an atom?
(a) $n = 5, l = 3, m = 0, s = +1/2$
(b) $n = 3, l = 2, m = -3, s = -1/2$
(c) $n = 3, l = 2, m = -2, s = -1/2$
(d) $n = 4, l = 0, m = 0, s = -1/2$ *(2009)*

56. Consider the following sets of quantum numbers:

	n	l	m	s
(i)	3	0	0	+1/2
(ii)	2	2	1	+1/2
(iii)	4	3	–2	–1/2
(iv)	1	0	–1	–1/2
(v)	3	2	3	+1/2

Which of the following sets of quantum number is not possible?
(a) (i), (ii), (iii) and (iv)
(b) (ii), (iv) and (v)
(c) (i) and (iii)
(d) (ii), (iii) and (iv) *(2007)*

57. The orientation of an atomic orbital is governed by
(a) principal quantum number
(b) azimuthal quantum number
(c) spin quantum number
(d) magnetic quantum number. *(2006)*

58. The following quantum numbers are possible for how many orbitals?
$n = 3, l = 2, m = +2$
(a) 1 (b) 2
(c) 3 (d) 4 *(2001)*

59. For which of the following sets of four quantum numbers, an electron will have the highest energy?

	n	l	m	s
(a)	3	2	1	+1/2
(b)	4	2	– 1	+1/2
(c)	4	1	0	–1/2
(d)	5	0	0	–1/2

(1994)

60. Electronic configuration of calcium atom can be written as
(a) $[Ne]4p^2$ (b) $[Ar]4s^2$
(c) $[Ne]4s^2$ (d) $[Kr]4p^2$ *(1992)*

61. In a given atom no two electrons can have the same values for all the four quantum numbers. This is called
(a) Hund's Rule
(b) Aufbau principle
(c) Uncertainty principle
(d) Pauli's Exclusion principle. *(1991)*

62. For azimuthal quantum number $l = 3$, the maximum number of electrons will be

(a) 2 (b) 6
(c) 0 (d) 14 *(1991)*

63. The order of filling of electrons in the orbitals of an atom will be

(a) $3d, 4s, 4p, 4d, 5s$ (b) $4s, 3d, 4p, 5s, 4d$
(c) $5s, 4p, 3d, 4d, 5s$ (d) $3d, 4p, 4s, 4d, 5s$ *(1991)*

64. The electronic configuration of Cu (atomic number 29) is

(a) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^9$
(b) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$
(c) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 4p^6 5s^2 5p^1$
(d) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 4p^6 3d^3$ *(1991)*

65. The total number of electrons that can be accommodated in all the orbitals having principal quantum number 2 and azimuthal quantum number 1 are

(a) 2 (b) 4
(c) 6 (d) 8 *(1990)*

66. An ion has 18 electrons in the outermost shell, it is

(a) Cu^+ (b) Th^{4+}
(c) Cs^+ (d) K^+ *(1990)*

67. Number of unpaired electrons in N^{2+} is/are

(a) 2 (b) 0
(c) 1 (d) 3 *(1989)*

68. The maximum number of electrons in a subshell is given by the expression

(a) $4l - 2$ (b) $4l + 2$
(c) $2l + 2$ (d) $2n^2$ *(1989)*

69. The number of spherical nodes in $3p$ orbitals are/is

(a) one (b) three
(c) none (d) two *(1988)*

ANSWER KEY

1.	(a)	**2.**	(b)	**3.**	(a)	**4.**	(a)	**5.**	(a)	**6.**	(c)	**7.**	(d)	**8.**	(a)	**9.**	(a)	**10.**	(b)
11.	(c)	**12.**	(d)	**13.**	(b)	**14.**	(b)	**15.**	(c)	**16.**	(b)	**17.**	(c)	**18.**	(a)	**19.**	(d)	**20.**	(d)
21.	(d)	**22.**	(c)	**23.**	(c)	**24.**	(b)	**25.**	(a)	**26.**	(b)	**27.**	(c)	**28.**	(c)	**29.**	(c)	**30.**	(b)
31.	(a)	**32.**	(c)	**33.**	(d)	**34.**	(c)	**35.**	(d)	**36.**	(b)	**37.**	(c)	**38.**	(c)	**39.**	(c)	**40.**	(a)
41.	(c)	**42.**	(b)	**43.**	(c)	**44.**	(d)	**45.**	(c)	**46.**	(a)	**47.**	(b)	**48.**	(b)	**49.**	(a)	**50.**	(c)
51.	(a)	**52.**	(b)	**53.**	(a)	**54.**	(d)	**55.**	(b)	**56.**	(b)	**57.**	(d)	**58.**	(a)	**59.**	(b)	**60.**	(b)
61.	(d)	**62.**	(d)	**63.**	(b)	**64.**	(b)	**65.**	(c)	**66.**	(a)	**67.**	(c)	**68.**	(b)	**69.**	(a)		

Hints & Explanations

1. (a) : $^{175}_{71}Lu$, Number of protons = Number of electrons = Atomic number = 71
Number of neutrons = Mass number – Atomic number = 175 – 71 = 104

2. (b) :

Species	**No. of electrons**
Be^{2+}	2
H^+	0
Li^+	2
Na^+	10
Mg^{2+}	10

3. (a) : Species having same no. of electrons are called isoelectronic species.
The no. of electrons in $CO = CN^- = NO^+ = C_2^{2-} = 14$. So, these are isoelectronic species.

4. (a) : Since both CO and CN^- have 14 electrons, therefore these are isoelectronic species (*i.e.* having same number of electrons).

5. (a) : The number of electrons in O^{2-}, N^{3-}, F^- and Na^+ is 10 each, but number of electrons in Tl^+ is 80.

6. (c) : Lyman series : UV region
Balmer series : Visible region
Paschen series : IR region
Brackett series : IR region

7. (d) : $E = \frac{hc}{\lambda}$ [Given, $\lambda = 45$ nm $= 45 \times 10^{-9}$ m]

On putting the given values in the equation, we get

$$E = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{45 \times 10^{-9}} = 4.42 \times 10^{-18}\ \text{J}$$

8. (a) : $c = \upsilon\lambda$

$$\lambda = \frac{c}{\upsilon} = \frac{3 \times 10^{17}}{6 \times 10^{15}} = 50\ \text{nm}$$

9. (a) : We know that, $E = \frac{hcN_A}{\lambda}$

$= \frac{6.62\times10^{-27}\times3\times10^{10}\times6.02\times10^{23}}{\lambda} = \frac{1.1955\times10^{8}}{\lambda} = \frac{1.196\times10^{8}}{\lambda}$ ergs mol^{-1}

10. (b) : $E_1 = \frac{hc}{\lambda_1}$ and $E_2 = \frac{hc}{\lambda_2}$;

$\frac{E_1}{E_2} = \frac{hc}{\lambda_1}\times\frac{\lambda_2}{hc} = \frac{\lambda_2}{\lambda_1}$

or $\frac{25}{50} = \frac{\lambda_2}{\lambda_1}$ or $\frac{1}{2} = \frac{\lambda_2}{\lambda_1} \Rightarrow \lambda_1 = 2\lambda_2$

11. (c) : Applying $\upsilon = c/\lambda$,

$\lambda = \frac{c}{\upsilon} = \frac{3\times10^{8}}{8\times10^{15}} = 37.5\times10^{-9}$ m

$= 37.5$ nm $\approx 4\times10^{1}$ nm

12. (d) : $E = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{6.626\times10^{-34}\times3\times10^{8}}{3.03\times10^{-19}}$

$= 656$ nm

13. (b) : The longest wavelength means the lowest energy. We know that relation for wavelength

$\frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)$

(R_H, Rydberg constant = 109677 cm^{-1})

For $n_1 = 2$, $n_2 = 3$

$\frac{1}{\lambda} = 109677\left(\frac{1}{(2)^2}-\frac{1}{(3)^2}\right) = 15233$

or, $\lambda = \frac{1}{15233} = 6.56\times10^{-5}$ cm

$= 6.56\times10^{-7}$ m $= 656$ nm

14. (b) : The electron is more tightly bound in the smallest allowed orbit.

15. (c) : We know that

$\Delta E \propto \left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right]$, where $n_2 > n_1$

$\therefore$ $n = 6$ to $n = 5$ will give least energetic photon.

16. (b) : $E_n = -K\left(\frac{Z}{n}\right)^2$

$Z = 1$ for hydrogen; $n = 2$

$E_2 = \frac{-K\times1}{4} \Rightarrow E_2 = -328$ kJ mol^{-1}; $K = 4\times328$

$E_4 = \frac{-K\times1}{16} \Rightarrow E_4 = -4\times328\times\frac{1}{16} = -82$ kJ mol^{-1}

17. (c) : $E = h\upsilon$ or $\upsilon = E/h$

For H atom, $E = \frac{-21.8\times10^{-19}}{n^2}$ J atom^{-1}

$\Delta E = -21.8\times10^{-19}\left(\frac{1}{4^2}-\frac{1}{1^2}\right) = 20.44\times10^{-19}$ J atom^{-1}

$\upsilon = \frac{20.44\times10^{-19}}{6.626\times10^{-34}} = 3.08\times10^{15}$ s^{-1}

18. (a) : Kinetic energy $= \frac{1}{2}mv^2 = \left(\frac{\pi e^2}{nh}\right)^2\times2m$ $\left[\because v = \frac{2\pi e^2}{nh}\right]$

Total energy, $E_n = -\frac{2\pi^2 me^4}{n^2h^2} = -\left(\frac{\pi e^2}{nh}\right)^2\times2m = -K.E.$

$\therefore$ Kinetic energy $= -E_n$

Energy of first excited state is –3.4 eV.

$\therefore$ Kinetic energy of same orbit ($n = 2$) will be +3.4 eV.

19. (d) : Sommerfeld modified Bohr's theory considering that in addition to circular orbits electrons also move in elliptical orbits.

20. (d) : For n^{th} orbit of 'H' atom, $r_n = n^2\times r_1$

$\Rightarrow$ radius of 2nd Bohr's orbit.

$r_2 = 4\times r_1 = 4\times0.53 = 2.12$ Å

21. (d) : Energy of an atom when $n = 1$

$E_1 = -\frac{1312}{(1)^2} = -1312$ kJ mol^{-1}

Similarly energy when $n = 3$, $(E_3) = -\frac{1312}{(3)^2}$

$= -145.7$ kJ mol^{-1}

The energy absorbed when an electron jumps from $n = 1$ to $n = 3$,

$E_3 - E_1 = -145.7 - (-1312) = 1166.3$ kJ mol^{-1}

$= \frac{1166.3}{6.023\times10^{23}} = 193.6\times10^{-23}$ kJ

$= 193.6\times10^{-20}$ J [1 joule = 10^7 ergs]

$\Rightarrow 193.6\times10^{-13}$ ergs $= 0.1936\times10^{-10}$ ergs

22. (c) : Due to ground state, state of hydrogen atom (n) = 1; Radius of hydrogen atom (r) = 0.53 Å

Atomic no. of Li (Z) = 3

Now, radius of Li^{2+} ion $= r\times\frac{n^2}{Z} = 0.53\times\frac{(1)^2}{3} = 0.17$ Å

23. (c) : Energy of an electron in n^{th} Bohr orbit of hydrogen atom $= \frac{-13.6}{n^2}$ eV.

24. (b) : Both He and Li^{+} contain 2 electrons each.

25. (a) : Radius of n^{th} orbit of H-atom $= r_0n^2$

where r_0 = radius of the first orbit.

26. (b) : Bohr radius, $a_0 = 52.9$ pm

$n = 2$, $r_n = n^2 a_0 = (2)^2 a_0 = 4 \times 52.9$ pm $= 211.6$ pm

The angular momentum of an electron in a given stationary state can be expressed as in equation,

$$mvr = n \cdot \frac{h}{2\pi} = 2 \times \frac{h}{2\pi} = \frac{h}{\pi} \Rightarrow mvr\pi = h \quad \text{... (i)}$$

de-Broglie equation,

$$\lambda = \frac{h}{mv}; \ \lambda mv = h \quad \text{... (ii)}$$

From equations (i) and (ii), we get $\lambda = \pi r$

Putting the value of r, $\lambda = 211.6\ \pi$ pm

27. (c) : According to de-Broglie equation, $\lambda = \frac{h}{mv}$

Given, $h = 6.6 \times 10^{-34}$ J s ; $m = 0.66$ kg ; $v = 100$ m s^{-1}

$$\therefore \ \lambda = \frac{6.6 \times 10^{-34}}{0.66 \times 100} = 1 \times 10^{-35} \text{ m}$$

28. (c) : From Heisenberg uncertainty principle,

$$\Delta p \cdot \Delta x \geq \frac{h}{4\pi} \quad \text{or} \quad m\Delta v \times \Delta x \geq \frac{h}{4\pi}$$

$$\text{or } (m\Delta v)^2 \geq \frac{h}{4\pi} \qquad (\because \Delta x = \Delta p)$$

$$\text{or } \Delta v \geq \frac{1}{2m}\sqrt{\frac{h}{\pi}}$$

29. (c) : Uncertainty in momentum $(m\Delta v)$

$= 1 \times 10^{-18}$ g cm s^{-1}

Uncertainty in velocity (Δv)

$$= \frac{1 \times 10^{-18}}{9 \times 10^{-28}} = 1.1 \times 10^{9} \text{ cm s}^{-1}$$

30. (b) : $\Delta x \cdot m\Delta v = h/4\pi$

$$0.1 \times 10^{-10} \times 9.11 \times 10^{-31} \times \Delta v = \frac{6.626 \times 10^{-34}}{4 \times 3.143}$$

$$\therefore \ \Delta v = \frac{6.626 \times 10^{-34}}{0.1 \times 10^{-10} \times 9.11 \times 10^{-31} \times 4 \times 3.143}$$

$= 5.79 \times 10^{6}$ m s^{-1}

31. (a) : $\Delta x \times \Delta p = \frac{h}{4\pi}$

(Heisenberg uncertainty principle)

$$\Rightarrow \Delta x = \frac{6.62 \times 10^{-34}}{4 \times 3.14 \times 10^{-5}} = 5.27 \times 10^{-30} \text{ m}$$

32. (c) : $\lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-27} \text{ erg sec}}{1 \text{ g} \times 10^{4} \text{ cm/s}}$

$= 6.63 \times 10^{-31}$ cm $= 6.63 \times 10^{-33}$ m

33. (d) : According to uncertainty principle the product of uncertainty in position and uncertainty in momentum is constant for a particle.

i.e., $\Delta x \times \Delta p = \frac{h}{4\pi}$

As, $\Delta x = 1.0$ nm for both electron and helium atom, so Δp is also same for both the particles.

Thus, uncertainty in momentum of the helium atom is also 5.0×10^{-26} kg m s^{-1}.

34. (c) : Mass of an electron $(m) = 9.1 \times 10^{-28}$ g

Velocity of electron $(v) = 3 \times 10^{4}$ cm/s

Accuracy $= 0.001\% = \frac{0.001}{100}$ and

Planck's constant $(h) = 6.626 \times 10^{-27}$ erg-second.

We know that actual velocity of the electron

$$(\Delta v) = 3 \times 10^{4} \times \frac{0.001}{100} = 0.3 \text{ cm/s}$$

Therefore, uncertainty in the position of the electron,

$$(\Delta x) = \frac{h}{4\pi m\Delta v} = \frac{6.626 \times 10^{-27}}{4\pi \times (9.1 \times 10^{-28}) \times 0.3} = 1.93 \text{ cm}$$

35. (d) : It is Heisenberg's uncertainty principle and not Bohr's postulate.

36. (b) : Higher the value of $(n + l)$ for an orbital, higher is its energy. However, if two different types of orbitals have same value of $(n + l)$, the orbital with lower value of n has lower energy. Therefore, decreasing order of energy of the given orbitals is $5f > 6p > 5p > 4d$.

37. (c) : Number of spherical/radial nodes in any orbital $= n - l - 1$

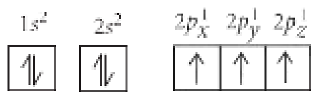
Number of planar/angular nodes in orbital $= l = 3$

$\therefore$ Total number of nodes in any orbital $= n - 1 = 3$

$\therefore$ $n = 4$

Thus, the orbital is $4f$.

38. (c) : According to Hund's rule of maximum multiplicity, the correct configuration of 'N' is



39. (c) : In case of hydrogen like atoms, energy depends on the principal quantum number only. Hence, $2s$-orbital will have energy equal to $2p$-orbital.

40. (a) : For $n = 3$ and $l = 1$, the subshell is $3p$ and a particular $3p$ orbital can accommodate only 2 electrons.

41. (c) : $d_{x^2-y^2}$ and d_{z^2} orbitals have electron density along the axes while d_{xy}, d_{yz} and d_{xz} orbitals have electron density in between the axes.

42. (b) : For the two electrons occupying the same orbital values of n, l and m_l are same but m_s is different, *i.e.*, $+\frac{1}{2}$ and $-\frac{1}{2}$.

43. (c) : Ti(22) : $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^2$

$\therefore$ Order of increasing energy is $3s$, $3p$, $4s$, $3d$.

44. (d) : Number of d-electrons in $Fe^{2+} = 6$
Number of p-electrons in Cl = 11

45. (c) : Angular momentum $= \sqrt{l(l+1)}\,\hbar$
For d-orbital, $l = 2$
Angular momentum $= \sqrt{2(2+1)}\,\hbar = \sqrt{6}\,\hbar$

46. (a) : Only one orbital, $3p_z$ has following set of quantum numbers, $n = 3$, $l = 1$ and $m_l = 0$.

47. (b) : The orbital associated with $n = 3$, $l = 1$ is $3p$. One orbital (with $m = -1$) of $3p$-subshell can accommodate maximum 2 electrons.

48. (b) : The electronic configuration of $_{64}Gd$ is $[Xe]4f^7 5d^1 6s^2$.

49. (a) : $l = 3$ and $n = 4$ represents $4f$. So, total number of electrons in a subshell $= 2(2l + 1) = 2(2 \times 3 + 1) = 14$ electrons. Hence, f-subshell can contain maximum 14 electrons.

50. (c) : Rb(37) : $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^1$
For $5s$, $n = 5$, $l = 0$, $m = 0$, $s = +1/2$ or $-1/2$

51. (a) : Orbital angular momentum (m)

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

For p-electrons; $l = 1$

$$\text{Thus, } m = \sqrt{1(1+1)}\,\frac{h}{2\pi} = \frac{\sqrt{2}\,h}{2\pi} = \frac{h}{\sqrt{2}\,\pi}$$

52. (b) : Total number of atomic orbitals in any energy level is given by n^2.

53. (a)

54. (d) : For a given shell, l,
the number of subshells, $m_l = (2l + 1)$
Since each subshell can accommodate 2 electrons of opposite spin, so maximum number of electrons in a subshell $= 2(2l + 1) = 4l + 2$.

55. (b) : In an atom, for any value of n, the values of $l = 0$ to $(n - 1)$.
For a given value of l, the values of $m_l = -l$ to 0 to $+l$ and the value of $s = +1/2$ or $-1/2$.
In option (b), $l = 2$ and $m_l = -3$
This is not possible, as values of m_l which are possible for $l = 2$ are $-2, -1, 0, +1$ and $+2$ only.

56. (b) : (i) represents an electron in $3s$ orbital.
(ii) is not possible as value of l varies from $0, 1, \ldots (n-1)$.
(iii) represents an electron in $4f$ orbital.
(iv) is not possible as value of m varies from $-l \ldots +l$.
(v) is not possible as value of m varies from $-l \ldots +l$, it can never be greater than l.

57. (d) : Principal quantum number represents the name, size and energy of the shell to which the electron belongs. Azimuthal quantum number describes the spatial distribution of electron cloud and angular momentum. Magnetic quantum number describes the orientation or distribution of electron cloud. Spin quantum number represents the direction of electron spin around its own axis.

58. (a) : $n = 3$, $l = 2$, $m = +2$
It symbolises one of the five d-orbitals ($3d$).

$m = +2$	$+1$	0	-1	-2

59. (b) : Energy of electron depends on the value of $(n + l)$. The subshell are $3d$, $4d$, $4p$ and $5s$, out of which $4d$ has highest energy.

60. (b) : Atomic no. of Ca = 20
$\therefore$ Electronic configuration of Ca = $[Ar]4s^2$

61. (d) : This is a Pauli's exclusion principle.

62. (d) : $l = 3$ means f-subshell

f-subshell =

↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓

63. (b) : Higher the value of $(n + l)$ for an orbital, higher is its energy. However, if two different types of orbitals have same value of $(n + l)$, the orbital with lower value of n has lower energy.

64. (b) : Electronic configuration of Cu is
$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$.

65. (c) : $n = 2$, $l = 1$
It means $2p$-orbitals.
Total no. of electrons that can be accommodated in all the $2p$ orbitals = 6

66. (a) : Cu^+ ion has 18 electrons in its outermost shell.
Electronic configuration of Cu^+ is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$.

67. (c) : $N^{2+} = 1s^2 2s^2 2p^1$
$\therefore$ No. of unpaired electrons = 1

68. (b) : No. of orbitals in a subshell $= 2l + 1$
$\Rightarrow$ No. of electrons $= 2(2l + 1) = 4l + 2$

69. (a) : No. of radial nodes in $3p$-orbital $= n - l - 1$
$= 3 - 1 - 1 = 1$