Atomic structure

SOLUTIONS

Level – I

ATOMIC TERMS

1. In the following reaction $_3Li^6 + ? \longrightarrow {_2He^4} + {_1H^3}$, the missing particle is

(1) Neutron (2) Proton (3) Electron (4) Deuterium

$3^{Li^6} + O^{n^1} \longrightarrow {_2He^4} + {_1H^3}$

2. $_6C^{11}$ and $_5B^{11}$ are called

(1) Nuclear isomers (2) Isobars

(3) Isotopes (4) Fission products

Isobars have same mass no. with diff at no.

3. Which one of the following sets of the ions represents the collection of isoelectronic species

(1) $Na^+, Mg^{+2}, Al^{+3}, Cl^-$ (2) $Na^+, Ca^{+2}, Sc^{+3}, F^-$

(3) $K^+, Mg^{+2}, Sc^{+3}, Cl^-$ (4) $K^+, Ca^{+2}, Sc^{+3}, Cl^-$

K^+	Ca^{2+}	SC^{3+}	Cl^-
19–1	20–2	21–3	17+1
=18	=18	=18	=18

4. The increasing order (lowest first) for the magnitude of e/m (charge/mass) for electron (e), proton (p), neutron (n) and alpha particle (α) is

(1) e, p, n, α (2) n, p, e, α (3) n, p, α, e (4) n, α, p, e

$\frac{e}{m}$ for neutrom is zero. For others specific charge ratio $\propto \frac{1}{mass}$

So order will be $n < \alpha < p < e^-$

5. X^{2-} has 56 electrons, the atomic number X is

(1) 56 (2) 58 (3) 28 (4) 54

No of protons = 56 – 2 = 54

6. $_{11}Na^{23}$ and $_{12}Mg^{24}$ are

(1) Isotopes (2) Isobars (3) Isodiaphers (4) Isotones

	$_{11}Na^{23}$	$_{12}Mg^{24}$
A–Z	23–11	24–12
	=12	=12

7. Particles in cathode ray has same charge/ mass ratio as of

(1) α particle (2) β particle (3) γ particle (4) proton

β particles are high velocity

8. During Muliken's oil drop experiment, out of the following, which is not a possible charge on oil droplet?

(1) 1.6×10^{-19} C (2) 2.4×10^{-19} C (3) 3.2×10^{-19} C (4) 4.8×10^{-19} C

2.4×10^{-19} C **is not a multiple of** 1.6×10^{-19} C

9. Rutherford's experiment on scattering of α-particles showed for the first time that the atom has

(1) electrons (2) protons (3) nucleus (4) neutrons

Rutherford discover a nucleus

INTRODUCTION TO WAVES

10. Which of the following is correct order of decreasing wavelength of electromagnetic spectrum

(1) Radio wave, γ-rays, Infrared, Red

(2) Radio wave, Yellow, Blue, Cosmic rays

(3) Micro wave, γ-rays, Infrared, Violet

(4) Ultraviolet, γ-rays, X-rays, Green

Electromagnetic spectrum cosmic rays < ν - rays < x-rays < u.v. < visible < I.R. < Microwaves < Radios waves.

11. Yellow light is more energetic than

(1) Violet (2) blue (3) Indigo (4) Red

Energy $\propto$ frequency

Frequency violet < Indigo < Blue < Green < Yellow < Red

12. The wave number of radiation of wavelength 500 nm is

(1) $5 \times 10^{-7}\ m^{-1}$ (2) $2 \times 10^{7}\ m^{-1}$ (3) $2 \times 10^{6}\ m^{-1}$ (4) $500 \times 10^{-9}\ m^{-1}$

$$2J = \frac{1}{\lambda} = \frac{1}{500\times10^{-9}} = \frac{10^7}{5} = 2\times10^6 m^{-1}$$

13. The ratio of the energy of a photon of 2000Å wavelength radiation to that of 4000Å radiation is

(1) 1/4 (2) 1/2 (3) 2 (4) 4

$$\frac{E_1}{E_2} = \frac{\lambda_2}{\lambda_1} = \frac{4000}{2000} = 2$$

14. Radio city broadcasts on a frequency of 5,090 KHz. What is the wavelength of electromagnetic radiation emitted by the transmitter?

(1) 10.3 m (2) 58.9 m (3) 60.5 m (4) 75.5 m

$$\lambda = \frac{C}{11} = \frac{3\times10^8}{5090\times10^3} = 58.9m$$

15. Find the energy range of photon belonging to the visible region. Given: λ_{Violet}=3800A^0 and λ_{Red}=7600A^0

(1) 1.63 eV to 3.26 eV (2) 4.3 eV to 8.6 eV

(3) 2 eV to 4eV (4) None

$$E = \frac{12400}{-1(A^\circ)} ev$$

$$\frac{12400}{7000} = 1.63eV \text{ to } \frac{12400}{3800} = 3.26 ev$$

16. What should be the frequency (in cycle per second) of an ultraviolet wave, if its wavelength is 25 A^0 and speed of light is c =3×10^8

(1) 12×10^{16} (2) 12×10^{8} (3) 75×10^{8} (4) 75×10^{16}

$$2 = \frac{C}{\lambda} = \frac{3\times10^{8}}{25\times10^{-10}} = 12\times10^{16}\,\text{CPS}$$

BOHR'S MODEL

17. An electron in an atom jumps in such a way that its kinetic energy changes from x to $\frac{x}{4}$. the change in potential energy will be:

(1) $+\frac{3}{2}x$ (2) $-\frac{3}{8}x$ (3) $+\frac{3}{4}x$ (4) $-\frac{3}{4}x$

$$\text{K.E.} = \frac{-1}{2}\text{P.E.}$$

$$\frac{x}{4} = -\frac{1}{2}\text{P.E}_2$$

$$x = -\frac{1}{2}\text{P.E}_1$$

$$\text{P.E}_2 = -\frac{x}{2}$$

$$\text{P.E}_1 = -2x$$

$$\text{P.E}_1 - \text{P. E}_2 = -2x + \left(\frac{-x}{x}\right)$$

$$= -2x + \frac{x}{2}$$

$$= \frac{-3x}{2}$$

$$\text{P.E}_2 - \text{P.E}_1 = \frac{3x}{2}$$

18. The binding energy of 1st excited state of Li^{2+} is

(1) 3.4 eV (2) 6.8 eV (3) 13.6 eV (4) 30.6 eV

$$E = -13.6\times\frac{(3)^2}{(2)^2} = 30.6\text{ev}$$

$$\text{B.E.} = -E$$

19. The ratio of velocity of the electron in the third and fifth orbit of Li^{2+} would be:

(1) 3:5 (2) 5:3 (3) 25:9 (4) 9:25

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

20. If Bohr's radius is $5\,A^0$ then radius of 1st excited state of He^+ orbit will be:

(1) $5\,A^0$ (2) $10\,A^0$ (3) $15\,A^0$ (4) $20\,A^0$

$r \propto \frac{n^2}{Z}$

$\frac{r}{5} = \frac{(2)^2}{2} = 2$

$r = 10\,\overset{o}{A}$

21. Which of the following statements does not form a part of Bohr's model of hydrogen atom ?
(1) Energy of the electrons in the orbit is quantized
(2) The electron in the orbit nearest to the nucleus has the lowest energy
(3) Electrons revolve in different orbits around the nucleus
(4) The position and velocity of the electrons in the orbit cannot be determined simultaneously.
Definition of Heinsengerg uncertainty principle.

22. According to Bohr's theory, the angular momentum of an electron in 5^{th} orbit is
(1) $25\frac{h}{\pi}$ (2) $1.0\frac{h}{\pi}$ (3) $10\frac{h}{\pi}$ (4) $2.5\frac{h}{\pi}$

$\frac{n_4}{2\pi} = \frac{5h}{2\pi}$

23. The spacing between the orbits in terms of distance is maximum in the case of
(1) 1^{st} and 2^{nd} (2) 2^{nd} and 3^{rd} (3) 3^{rd} and 4^{th} (4) 4^{th} and 5^{th}

$r = 0.529 \times \frac{n^2}{Z}$

As $\Delta n \uparrow \Delta r \uparrow$

24. The spacing between the orbits in terms of energy is maximum in the case of
(1) 1^{st} and 2^{nd} (2) 2^{nd} and 3^{rd} (3) 3^{rd} and 4^{th} (4) 4^{th} and 5^{th}

$E = -13.6 \times \frac{Z^2}{n^2} CV$

As $\Delta n \uparrow \Delta r \uparrow$

ATOMIC SPECTRUM

25. Transition of an electron from n = 4 to n = 2 level results (for a He^+ ion) in
(1) IR spectrum (2) UV spectrum
(3) Visible spectrum (4) X-ray spectrum
Wavelength of n = 4 to n = 2 lint in He^+ is identical to n = 2 to n = 1 in Hydrogen spectrum.

26. The wavelength of first line of Lyman series is $1216\,A^0$. What is the wavelength of last line of Lyman series
(1) $3648\,A^0$ (2) $608\,A^0$ (3) $912\,A^0$ (4) $2432\,A^0$
For last line $n_2 = \infty$

$\frac{1}{\lambda_1} = R\left(\frac{1}{1^2} - \frac{1}{2^2}\right)$ For first line (1)

$\frac{1}{\lambda_2} = R\left(\frac{1}{1^2} - \frac{1}{\infty^2}\right)$ Last line (2)

Divide (1) by (2)

$$\frac{\frac{1}{\lambda_1}}{\frac{1}{\lambda_2}} = \frac{\frac{3}{4}}{1}$$

$$\Rightarrow \quad \lambda_2 = \frac{3}{4}\lambda$$

$$= \frac{3}{4}\times 1216$$

= 912 Å

27. In a sample of hydrogen atoms, if electron jumps from n = 6 to n = 2 , how many maximum possible spectral lines are obtained

(1) 15 (2) 10 (3) 6 (4) 12

No. of spectral line = $\frac{\Delta n(\Delta n+1)}{2} = \frac{5\times 4}{2} = 10$

28. What is the shortest wavelength line in the Paschen series of Li^{2+} ion?

(1) $\frac{R}{9}$ (2) $\frac{9}{R}$ (3) $\frac{1}{R}$ (4) $\frac{9R}{4}$

$$\frac{1}{\lambda} = R(3)^2\left[\frac{1}{(3)^2} - \frac{1}{\infty^2}\right] = R$$

$$\rightarrow \lambda = \frac{1}{R}$$

29. What is the longest wavelength line in the Lyman series of He^{+} ion?

(1) 3R (2) $\frac{1}{3R}$ (3) $\frac{1}{4R}$ (4) None of these

1st line

$$\frac{1}{\lambda} = R(2)^2\left[\frac{1}{1^2} - \frac{1}{2^2}\right] = 4R\left[1 - \frac{1}{4}\right]$$

$$\frac{1}{\lambda} = 4R\times\frac{3}{4} \Rightarrow \lambda = \frac{1}{3R}$$

30. An excited state of H atom emits a photon of wavelength λ and returns to the ground state, the principal quantum number of excited state is given by:

(1) $\sqrt{\lambda R(\lambda R-1)}$ (2) $\sqrt{\frac{\lambda R}{(\lambda R-1)}}$ (3) $\sqrt{\lambda R(\lambda R+1)}$ (4) $\sqrt{\frac{(\lambda R-1)}{\lambda R}}$

$$\frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{n^2}\right)$$

$$\frac{1}{\lambda} = R\frac{n^2-1}{n^2}$$

$$n^2 = \lambda R n^2 - \lambda R$$

$$n^2(\lambda R - 1) = \lambda R$$

$$n = \sqrt{\frac{\lambda R}{(\lambda R - 1)}}$$

31. A dye absorbs a photon of wavelength λ and re-emits the same energy into two photons of wavelength λ_1 and λ_2 respectively. The wavelength λ is related with λ_1 and λ_2 as:

(1) $\lambda = \frac{\lambda_1 + \lambda_2}{\lambda_1\lambda_2}$ (2) $\lambda = \frac{\lambda_1\lambda_2}{\lambda_1 + \lambda_2}$ (3) $\lambda = \frac{\lambda_1^2\lambda_2^2}{\lambda_1 + \lambda_2}$ (4) $\lambda = \frac{\lambda_1\lambda_2}{(\lambda_1 + \lambda_2)^2}$

$$E_3 = E_1 + E_2$$

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

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

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

32. A gas absorbs a photon of 355 nm and emits at two wavelengths. If one of the emissions is at 680 nm, the other is at :

(1) 325 nm (2) 743 nm (3) 518 nm (4) 1035 nm

$$\frac{1}{355} = \frac{1}{\lambda} + \frac{1}{680} \Rightarrow \frac{1}{\lambda} = \frac{1}{355} - \frac{1}{680}$$

$$\lambda = \frac{680 \times 355}{680 - 355}$$

$$\lambda = 743\text{nm}$$

33. The emission spectra are observed by the consequence of transition of electron from higher energy state to ground state in Li^{2+} ion. Six different types of photons are observed during the emission spectra, and then what is the excitation state of Li^{2+} ion?

(1) 3^{rd} (2) 4^{th} (3) 2^{nd} (4) 5^{th}

$$\frac{n(n-1)}{2} = 6$$

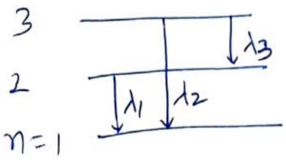
$$n(n-1) = 12$$

$$n = 4$$

3^{rd} excited state

34. If λ_1, λ_2, and λ_3, are wave length of photon corresponding to 1^{st}, 2^{nd} Lyman series and 1^{st}Balmer series respectively, which of the following statement is correct?

(1) $\lambda_2 = \lambda_1 + \lambda_3$ (2) $\lambda_2 = \lambda_1\lambda_3/(\lambda_1+\lambda_3)$ (3) $\lambda_1 + \lambda_2 + \lambda_3 = 0$ (4) $\lambda_2^2 = \lambda_1^2 + \lambda_3^2$



$$E_3 + E_1 = E_2$$

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

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

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

$$\frac{1}{x}=R\left[\frac{1}{12}-\frac{1}{\infty^2}\right]\Rightarrow\frac{1}{x}=R$$

$$\frac{1}{\lambda}=R(2)^2\left[\frac{1}{2^2}-\frac{1}{3^2}\right]=R(4)\left(\frac{5}{36}\right)$$

$$\frac{1}{\lambda}=\left(\frac{1}{x}\right)\left(\frac{5}{9}\right)\Rightarrow\lambda=\frac{9x}{5}$$

35. If the shortest wavelength of H atom in Lyman series is x, then longest wavelength in Balmer series of He^+ is

(1) $\frac{9x}{5}$ (2) $\frac{36x}{5}$ (3) $\frac{x}{4}$ (4) $\frac{5x}{9}$

de-BROGLIE DUAL NATURE PRINCIPLE

36. If E_1, E_2 and E_3 are kinetic energy of electron, alpha particle and proton having same de-Broglie wave length, then

(1) $E_1>E_2>E_3$ (2) $E_1<E_2<E_3$ (3) $E_2<E_3<E_1$ (4) $E_1=E_2=E_3$

$$\lambda\frac{h}{\sqrt{2mK}}$$

$m\uparrow k\downarrow$

as $m_\propto > m_p > m_e$

K.E $:\propto < P < e$

37. Calculate the wavelength (in nanometer) associated with a proton moving at 1.0×10^3 ms^{-1}. (Mass of proton $=1.67\times10^{-27}$ kg and h$=6.63\times10^{-34}$ Js)

(1) 0.032 nm (2) 0.40 nm (3) 2.5 nm (4) 14.0 nm

$$\lambda=\frac{6.62\times10^{-34}}{10^3\times1.67\times10^{-27}}=4\times10^{-10}\text{m}$$

$=0.4\text{nm}$

38. If travelling at equal speeds, the longest wavelength of the following matter waves is that of

(1) electron (2) proton
(3) neutron (4) alpha particle

$$\lambda=\frac{h}{mv}$$

$m\downarrow\lambda\uparrow$

39. Which of the following relates to photons both as wave motion and as a stream of particles?

(1) Interference (2) $E = mc^2$ (3) diffraction (4) $E = h\nu$

$E = hz$

UNCERTAINTY HEISENBERG PRINCIPLE

40. If the uncertainty in position of electron is zero, then the uncertainty in its momentum would be

(1) Zero (2) $\frac{h}{\pi}$ (3) $\frac{2h}{\pi}$ (4) infinite

$\Delta x \times \Delta p \geq \frac{h}{4\pi}$

If $\Delta x = 0$

Then Δp will be infinity.

41. When applied, the uncertainty principle has significance in case of

(1) Moving train (2) Spinning cricket ball

(3) Moving α- particle (4) All the above

It is applicable for microscopic particles only

QUANTUM MODEL

42. The number of nodal planes in a p_x orbital is

(1) one (2) two (3) three (4) zero

No. of nodal plane = ℓ

43. For a 4d electron the orbital angular momentum is: ($\hbar = h/2\pi$)

(1) $\sqrt{6}\,\hbar$ (2) $\sqrt{12}\,\hbar$ (3) $\sqrt{2}\,\hbar$ (4) zero

$\sqrt{\ell(\ell+1)}\frac{h}{2\pi} = \sqrt{2(2+1)}\frac{h}{2\pi} = \sqrt{6}\frac{h}{2\pi}$

44. Which subshell doesn't exist?

(1) 7s (2) 3d (3) 3f (4) 5d

If n = 3, $\ell \neq 3$

45. The quantum number not obtained from the Schrodinger's wave equation is

(1) n (2) l (3) m (4) s

n, ℓ, m are obtained from Schrodinger equation.

46. The orbital angular momentum of an electron in 2s orbital is

(1) $+\frac{1}{2}\cdot\frac{h}{2\pi}$ (2) zero (3) $\frac{h}{2\pi}$ (4) $\sqrt{2}.\frac{h}{2\pi}$

$\sqrt{0(0+1)}\frac{h}{2\pi} = 0$

47. Which quantum number determines shape of the orbital?

(1) Principal (2) Angular momentum (3) Magnetic (4) Spin

ℓ gives shape of orbitals

48. Radial nodes are maximum in:

(1) 4s (2) 4p (3) 3d (4) 5f

No. of radial nodes = n – ℓ – 1

4S : 3

4P : 2

3d : 0

5f : 2

49. Probability of finding the electron in the orbital is?

(1) 100% (2) 5-10% (3) 90-95% (4) 50-60%

Probability of finding electron is maximum (90-95%)
In orbital

50. The Wave mechanical model of atom is developed upon

(1) de Broglie concept of dual nature (2) Heisenberg's uncertainty principle
(3) Schrodinger wave equation (4) All of these

Wave mechanical model based on all of them P orbital can occupy maximum all of them.

51. Select the correct statement from following:

A: Splitting of spectra line occurs when placed in a magnetic field or in an electric field.
B: In case of 1s- orbital, the density of the electron cloud is the greatest near the nucleus and falls off with the distance.
C: Electron – density is concentrated along a particular direction in case of 2p-orbital
D: A p-orbital can take maximum of six electrons

(1) A, B, D (2) A, B, C (3) B, C, D (4) A, C, D

P orbital can occupy maximum two electrons

52. The Magnetic quantum number signifies

(1) Size of the orbital (2) Shape of the orbital
(3) Orientation of orbital in space (4) Nuclear stability

m givs orientation of orbitals

53. The quantum number which specifies the location as well as energy is

(1) n (2) l (3) m (4) s

Gives orientation of orbital in space.

54. Which of the following sets of quantum numbers is not allowed?

(1) n = 3, l = 1, m = +2 (2) n = 3, l = 1, m = +1
(3) n = 3, l = 0, m = 0 (4) n = 3, l = 2, m = ± 2

$m = -\ell \text{ to } +\ell$

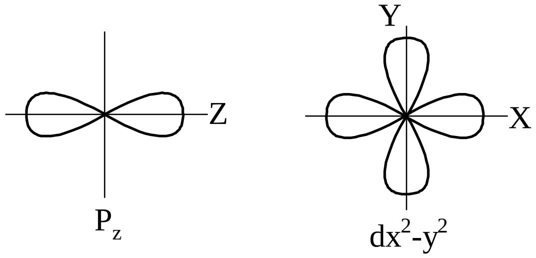
55. Which set of quantum numbers is not possible for electron in 3rd shell?

(1) n = 3, l = 2, m = – 1, s= +1/2 (2) n = 3, l = 2, m = – 1, s= –1/2
(3) n = 3, l = 2, m =0, s= +1/2 (4) n = 3, l = 3, m = 0, s= –1/2

$\ell = 0 \text{ to } n-1$

56. Which two orbitals are located along the axes, and not between the axes?

(1) d_{xy}, d_{z^2} (2) d_{xy}, p_z (3) d_{yz}, p_x (4) $p_z, d_{x^2-y^2}$



57. Which of the following set a of quantum numbers is correct for an electron in 4f orbital

(1) n = 4, l =3, m = +4, s = +1/2
(2) n = 4, l = 4, m = –4, s = –1/2
(3) n = 4, l = 3, m = +1, s = +1/2
(4) n = 3, l=2, m =–2, s = +1/2

$m = \ell \text{ to} + \ell$

$\ell = 0 \text{ to } n - 1$

$n = 4$

58. Which of the following is non-permissible?

(1) n = 4, l = 3, m = 0
(2) n = 4, l = 2, m = 1
(3) n = 4, l = 4, m = 1
(4) n = 4, l = 0, m = 0

$\ell = 0 \text{ to } n - 1$

ELECTRONIC CONFIGURATION

59. Out of the following which sub shell has maximum energy?

(1) 3d (2) 4s (3) 5s (4) 4p

$n + \ell \uparrow \text{energy} \uparrow$

For same $n + \ell$, $n \uparrow$ energy $\uparrow$

60. Which series of subshells is arranged in the order of increasing energy for multi-electron atoms?

(1) 6*s*, 4*f*, 5*d*, 6*p* (2) 4*f*, 6*s*, 5*d*, 6*p* (3) 5*d*, 4*f*, 6*s*, 6*p* (4) 4*f*, 5*d*, 6*s*, 6*p*

	6s		4f		5d		6p
$n + \ell$	6		7		7		7
Energy:	6s	<	4f	<	5d	<	6p

61. If the principal quantum number n = 6, the correct sequence of filling of electrons will be

(1) ns → np → (n – 1)d → (n – 2)f
(2) ns → (n – 2)f → (n – 1)d → np
(3) ns → (n – 1)d → (n – 2)f → np
(4) ns → (n – 2)f → np → (n – 1)d

$n + \ell \uparrow \text{energy} \uparrow$

For same $n + \ell$, $n \uparrow$ energy $\uparrow$

62. The electrons identified by quantum numbers n and l :

(1) n = 4, l = 1 (2) n = 4, l = 0 (3) n = 3, l = 2 (4) n = 3 , l = 1

Can be placed in order of increasing energy as :

(1) (3) < (4) < (2) < (1)
(2) (4) < (2) < (3) < (1)
(3) (2) < (4) < (1) < (3)
(4) (1) < (3) < (2) < (4)

$n + \ell \uparrow, E \uparrow$

63. Which of the following electronic configurations is correct for Iron, (atomic number 26)?

(1) $[Kr]4s^1 3d^6$ (2) $[Kr]4s^1 3d^7$ (3) $[Ar]4s^2 3d^6$ (4) $[Kr]4s^2 3d^6$

$n + \ell \uparrow, E \uparrow$

64. Which of the following representation of excited states of atoms is impossible?

(1) $1s^1 2s^1$ (2) $[Ne]3s^2 3p^3 4s^1$ (3) $[Ne]3s^2 3p^6 4s^1 3d^6$ (4) $1s^2 2s^2 2p^7 3s^2$

P cannot occupy 6 electrons

65. Which of the following has the maximum number of unpaired electrons?

(1) Mn (2) Ti (3) V (4) Al

$Mn = [Ar]4s^2 3d^5 \quad (n = 5)$

$Ti = [Ar]4s^2 3d^2 \quad (n = 2)$

$V = [Ar]4s^2 3d^3 \quad (n = 3)$

$Al = 15^2 2s^2 2p^6 3s^2 3p^1 \quad (n = 1)$

66. The magnetic moment of isolated Fe^{2+} ion is

(1) $2\sqrt{6}$ BM (2) $\sqrt{15}$ BM (3) $\sqrt{3}$ BM (4) $\sqrt{35}$ BM

$Fe^{2+} = [Ar]4s^o 3d^6$

$n = 4$

$\mu = \sqrt{4(4+2)} = \sqrt{24} = 2\sqrt{6}$ B.M

67. Total spin resulting from a d^5 configuration is

(1) 1 (2) ½ (3) 5/2 (4) 3/2

Total spin $= \frac{1}{2} \times$ **no. of unpaired electrons**

68. Electronic configuration of Ni is [Ar] $3d^8$ $4s^2$. The electronic configuration of next element is

(1) [Ar] $3d^{10}4s^1$ (2) [Ar] $3d^9$ $4s^2$ (3) $3d^8 4s^2 4p^1$ (4) None

$Cu = [Ar]4s^1 3d^{10}$

69. Which of the following violates the Pauli Exclusion Principle?

(1) [↑↓] [↑↓][ ][ ] (2) [↑↓] [↑][↓][↑]

(3) [↑↑] [↑][↑][↑] (4) [↑] [↑][↑][↑]

Pauli's state that no two e^{-s} in an orbital can have same spin.

70. The ratio of magnetic moments of Fe (III) and Co (II) is:

(1) $\sqrt{5}:\sqrt{7}$ (2) $\sqrt{35}:\sqrt{15}$ (3) 7 : 3 (4) $\sqrt{24}:\sqrt{15}$

$\mu = \sqrt{n(n+2)}$ B.M.

$$\frac{\mu_{Fe^{3+}}}{\mu_{Co^{2+}}} = \frac{\sqrt{35}}{\sqrt{15}}$$

71. Which of the following sets of quantum numbers, represents the 19^{th} electron of chromium?

	n	*l*	m	s
(1)	4	*1*	–1	1/2
(2)	4	*0*	0	1/2
(3)	3	*2*	–2	1/2
(4)	3	*2*	0	1/2

(2)

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

↑

$n = 4, \ell = 0, m = 0, s = \pm\frac{1}{2}$

72. The correct set of four quantum numbers for the valence electrons of rubidium atom is

(1) $5, 1, 0, +\frac{1}{2}$ (2) $5, 1, 1, +\frac{1}{2}$ (3) $5, 0, 1, +\frac{1}{2}$ (4) $5, 0, 0, +\frac{1}{2}$

$[Kr]5s^1$

$n = 5, \ell = 0, m = 0, s = \pm\frac{1}{2}$

73. According to Pauli's exclusion principle

(1) No two electron can have the same energy in an orbital
(2) No two electron can have the parallel spin in an orbital
(3) As far as possible the electron fill in different orbitals
(4) Electron try to occupy the orbital of lower energy

E.C. of Rubidium (Z = 37) is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^1$. So set of quantum nos. 5, 0, 0, $\frac{+1}{2}$.

74. Which of the following statement is false

(1) (n+l) rule arranges the orbitals in increasing order of energy
(2) Wavelength of a particle is inversely proportional of its momentum
(3) Aufbau's principle was given by a scientist named Aufbau
(4) Velocity of all types of electromagnetic radiation is same

No two e^- of an atom can have same set of four quantum nos acc. To Pauli's Principle.

Level–II

ATOMIC TERMS

1. Assuming the nucleus and an atom to be spherical, the radius of the nucleus of mass number A is given by $1.25\times10^{-13}\times A^{1/3}$ cm. The atomic radius of atom is 1 A^o. If the mass number is 64, the fraction of the atomic volume that is occupied by the nucleus is

(1) 1.25×10^{-13} (2) 2.5×10^{-13} (3) 5×10^{-5} (4) one

Radius of nucleus = $1.25\times64^{1/3}\times10^{-13}$ cm

$= 1.25\times4\times10^{-13}$ cm

$= 5\times10^{-13}$ cm

Radius of atom = 10^{-8} cm

$$\frac{\text{volume of nucleus}}{\text{volume of atom}} = \frac{\frac{4}{3}\pi r^3}{\frac{4}{3}\pi R^3} = \frac{125\times(10^{-13})^3}{(10^{-8})^3} = 1.25\times10^{-13}$$

INTRODUCTION TO WAVES

2. A 1000 watt radio transmitter operates at a frequency of 880 kilocycle/sec. How many photons per sec does it emit?

(1) 2.01×10^{29} (2) 1.72×10^{30} (3) 1.51×10^{29} (4) 1.77×10^{31}

$1000 = n\times6.62\times10^{-34}\times880\times10^3$

$n = 1.72\times10^{30}$

3. The eyes of certain members of reptile family pass a visual signal to the brain when the visual receptors are struck by photons of wavelength 890 nm. If a total energy of 3.15×10^{-14} J is required to trip signal, what is the minimum number of photons that must strike the receptor?

(1) 3.05×10^{19} (2) 1.72×10^{9} (3) 1.41×10^{5} (4) 2.75×10^{10}

$$3.15\times10^{-14} = \frac{n\times2\times10^{-25}}{890\times10^{-9}}$$

$$n = 1.4\times10^{5}$$

4. A certain dye absorbs light of wavelength 4500 A° and then emits fluorescence light of 5000A°. Assuming that, under given conditions 50% of the absorbed energy is re-emitted out as fluorescence. Calculate the ratio of quanta emitted to the number of quanta absorbed

(1) 0.55 (2) 2.1 (3) 1.8 (4) 0.75

$$E_{absorb} = n_a \frac{hc}{\lambda_a}$$

$$E_{emitted} = n_e \frac{hc}{\lambda_e}$$

$$\frac{E_e}{E_a} = \frac{\lambda_a}{\lambda_e}\times\frac{n_e}{n_a}$$

$$E_e = 0.5E_a$$

$$0.5 = \frac{4500}{5000}\times\frac{n_e}{n_a}$$

$$\frac{n_e}{n_a} = 0.5\times\frac{50}{45} = 0.55$$

5. Two wave differ in frequency by 10^{15} Hz. If one wave has $\lambda = 4000\,A^0$. What is the wavelength of other wave

(1) $3000\,A^0$ (2) $1715\,A^0$ (3) $6000\,A^0$ (4) $3440\,A^0$

$$\nu_1 = \frac{3\times10^8}{4000\times10^{-10}} = 0.75\times10^{15}$$

$$\nu_2 = 10^{15} + 0.75\times10^{15}$$

$$= 1.75\times10^{15} \quad H_2$$

$$\lambda_2 = \frac{C}{\nu_2} = \frac{3\times10^8}{1.75\times10^{15}} = 1.714\times10^{-7}\,m$$

$$= 1714\,\overset{o}{A}$$

6. If 10^{-17} J of the light is needed by the interior of human eye to see an object. The photons of green light (λ =550 nm) needed to see the object are

(1) 27 (2) 28 (3) 29 (4) 30

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

$$10^{-17} = n\times\frac{6.626\times10^{-34}\times3\times10^8}{550\times10^{-9}\,m}$$

n = 28

7. Ionization energy of gaseous Na atoms 495.5 kJ mol^{-1}. The lowest possible frequency of light that ionizes a sodium atom is $\left(h = 6.626\times10^{-34}\ \text{Js},\ N_A = 6.022\times10^{23}\ \text{mol}^{-1}\right)$

(1) $7.50\times10^4\ s^{-1}$ (2) $4.76\times10^{14}\ s^{-1}$

(3) $3.15\times10^{15}\ s^{-1}$ (4) $1.24\times10^{15}\ s^{-1}$

$$h_2 = \frac{495.5\times10^3}{6.02\times10^{23}}\ \text{J latom}$$

$$\nu = \frac{495.5\times10^{-20}}{6.02\times6.62\times10^{-34}} = 1.24\times10^{15}\ \text{HZ}$$

8. The energy required to break one mole of Cl – Cl bonds in Cl_2 is 242 kJ mol^{-1}. The longest wavelength of light capable of breaking a single Cl – Cl bond is
($c = 3 \times 10^8$ m s^{-1} and NA = 6.02×10^{23} mol^{-1})

(1) 594 nm (2) 640 nm (3) 700 nm (4) 494 nm

$$E = \frac{242\times10^3}{6.02\times10^{23}}\ \text{J / molecule}$$

$$E = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{E} = \frac{2\times10^{-25}}{242\times10^3}\times6.02\times10^25$$

$$\lambda = 0.0495\times10^{-5}\ \text{m}$$

$$= 495\text{nm}$$

9. 242 nm is just sufficient to ionize sodium atom. Ionization energy of sodium atom will be

(1) 494 kJ mol^{-1} (2) 24.7 kJ mol^{-1}

(3) 988 kJ mol^{-1} (4) 247 kJ mol^{-1}

$$E = \frac{2\times10^{-25}}{6.02\times10^{23}}\ \text{J latom}$$

$$= \frac{2\times10^{-25}\times6.02\times10^{23}}{242\times10^{-9}\times10^3}\ \text{kJ / mol}$$

=494 kJ / mol

BOHR'S MODEL

10. The potential energy of an electron in the Hydrogen atom is – 6.8 eV. Indicate in which excited state, the electron is present?

(1) First (2) second (3) third (4) fourth

$$\text{T.E.} = \frac{1}{2}\text{P.E.} = \frac{1}{2}\times-6.8 = -3.4\,\text{eV}$$

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

$$-3.4 = \frac{-13.6}{n^2}$$

n = 2 i.e. first excited state.

11. What is the potential energy of an electron present in *N*-shell of the Be^{3+} ion?

(1) – 3.4 eV (2) – 6.8 eV (3) – 13.6 eV (4) – 27.2 eV

n = 4

$$\text{P.E} = 2\times 13.6\times\frac{(4)^2}{(4)^2} = -27.2\text{eV}$$

12. The kinetic and potential energy (in eV) of electron present in third Bohr's orbit of hydrogen atom are respectively:

(1) – 1.51, – 3.02 (2) 1.51, – 3.02 (3) – 3.02, 1.51 (4) 1.51, – 1.51

$$\text{K.E} = +13.6\times\frac{(1)^2}{(3)^2} = 1.51\text{eV}$$

$$\text{P.E.} = -2(1.51) = -3.02\text{eV}$$

13. What is the atomic number (Z) correspond to which 4^{th} orbit would fit inside the 1^{st} Bohr orbit of H-atom?

(1) 3 (2) 4 (3) 16 (4) 25

$$0.529\times\frac{(4)^2}{2} < 0.529$$

$$(4)^2 < Z \Rightarrow Z > 16$$

14. Which state of Be^{3+} has the same orbit radius as that of the ground state of hydrogen atom?

(1) 3 (2) 2 (3) 4 (4) 5

$$0.529\times\frac{n^2}{(4)} = 0.529\times\frac{(1)^2}{(1)}$$

$$n = 2$$

15. According to Bohr's theory, the energy of an excited state of He^+ is -13.6 eV then what is the angular momentum of an electron

(1) $\frac{2h}{\pi}$ (2) $\frac{h}{\pi}$ (3) $\frac{3h}{\pi}$ (4) $\frac{4h}{\pi}$

$$-13.6\times\frac{(2)^2}{n^2} = -13.6$$

$$n = 2$$

$$\text{Angular momentum} = \frac{nh}{2\pi} = \frac{2h}{2\pi} = \frac{h}{\pi}$$

16. If the revolutions per second by the electron in 3^{rd} orbit of H is δ, then the revolutions per second by the electron in 2^{nd} orbit of He^+ is

(1) δ (2) 13.5δ (3) 1.5δ (4) 0.07δ

$$\frac{\nu_3}{\nu_2} = \frac{v_3}{2\pi r_3}\times\frac{2\pi r_2}{v_2}$$

$$= \frac{\frac{1}{3}}{9}\times\frac{\frac{4}{2}}{\frac{2}{2}} = \frac{1}{27}\times 2 = \frac{2}{27}$$

$$\nu_2 = \frac{27}{2}\nu_3 = 13.5d$$

17. If the kinetic energy of electron moving in 4^{th} orbit of hydrogen is €, then the total energy in 1^{st} orbit of Li^{2+} is

(1) –144 € (2) –0.0069 € (3) –(27/9) € (4) – €

T.E.= - K.E.

= -E

$$E_4 = -\frac{E_1}{16}$$

$$E_1 = 16E$$

$$E_{1H^{2+}} = -E_1 \times Z^2$$

= - 16 × 9

= – 144 E

18. If same energy is supplied to electron in ground state of Hydrogen as well as He^+, electron jump to 5^{th} main shell in Hydrogen, then final orbit of electron in He^+ is

(1) 2^{nd} (2) 1^{st} (3) 3^{rd} (4) 4^{th}

Energy given to both

$$= \left[-13.6 \times \frac{1^2}{(5)^2}\right] - \left[-13.6 \times \frac{1^2}{1^2}\right]$$

$$= 13.6\left(1 - \frac{1}{25}\right) = 13.6 \times \frac{24}{25}$$

Energy required for Ht^+ electron to jump from 1^{st} orbit to 2^{nd} orbit is 54.4ev which is much greater than $13.6 \times \frac{24}{25}$ eV. Therefore electron remains in 1^{st} orbit only.

19. 400 unit of energy is required to take away an electron from lowest energy state to infinity in a H- like atom. What is the amount of energy released when an electron jumps from infinity to the second orbit in that atom

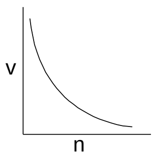
(1) 400 unit (2) 100 unit (3) 1600 unit (4) 200 unit

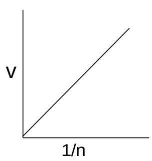
$$E_\infty - E_2 = 0 - \left(\frac{-E_1}{4}\right)$$

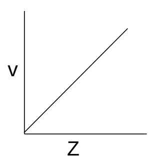
E_1 = 400 units

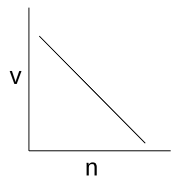
$$E_\infty - E_2 = 100 \text{ units}$$

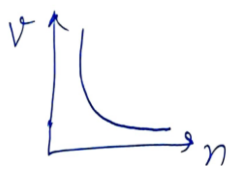
20. Select the incorrect graph for velocity of e^- in an orbit *Vs*. Z $\frac{1}{n}$ and n:

(1)


(2)


(3)


(4)




21. The distance between 4th and 3rd Bohr orbits of He^+ is:

(1) 2.645×10^{-10} m (2) 1.322×10^{-10} m (3) 1.851×10^{-10} m (4) None

$$r_4 - r_3 = \frac{0.529}{2}\times(4^2-3^2)$$

$$= \frac{0.529}{2}(16-9)\text{Å}$$

$= 1.851 \times 10^{-10}$ m

22. What is the frequency of revolution of electron present in 2nd Bohr's orbit of H-atom?

(1) $1.016\times10^{16}\,s^{-1}$ (2) $4.065\times10^{16}\,s^{-1}$

(3) $1.626\times10^{15}\,s^{-1}$ (4) $8.2\times10^{14}\,s^{-1}$

$$\frac{v}{2\pi r} = 6.56\times10^{15}\times\frac{z^2}{n^3}$$

$$= 6.56\times10^{15}\times\frac{(1)^2}{(2)^3}$$

$$= 8.2\times10^{14}$$

23. According to Bohr's theory, angular momentum of electron in any orbit of Hydrogen is directly proportional to

(1) $\sqrt{\frac{1}{r_n}}$ (2) $\frac{1}{r_n}$ (3) $r_n^{\,2}$ (4) $\sqrt{r_n}$

$$mvr = \frac{nh}{2\pi}$$

$$mvr \propto n$$

$$r \propto n^2 \Rightarrow mvr \propto n \propto \sqrt{r}$$

24. If force of attraction between the electron and nucleus in 2nd orbit of Li^{2+} is f, force of attraction if electron present in 1st orbit of H is

(1) $\frac{6}{19}f$ (2) $\frac{12}{25}f$ (3) $\frac{8}{81}f$ (4) $\frac{16}{27}f$

$$E = F.r_n$$

$$F = \frac{E}{r_n}$$

$$F \propto \frac{Z^2}{n^2.\frac{n^2}{z}}$$

$$\propto \frac{Z^3}{n^4}$$

25. The ionization enthalpy of hydrogen atom is $1.312\times10^6\,J\ mol^{-1}$. The energy required (in $J\ mol^{-1}$) to excite the electron in the atom from n = 1 to n = 2 is

(1) 9.84×10^5 (2) 8.51×10^5 (3) 6.56×10^5 (4) 7.56×10^5

$E_1 = -1.132\times10^6$

$E_2 = \dfrac{-1.312\times10^6}{(2)^2}$

$\Delta E = E_2 - E_1 = 1.312\times10\left(1-\dfrac{1}{4}\right)$

$= \dfrac{3}{4}\times1.312\times10^6$

$= 9.84\times10^5 J/mol$

26. Energy of an electron is given by $E = -2.178\times10^{-18}\times\dfrac{z^2}{n^2}$. Wavelength of light required to excite an electron in the hydrogen atom from level n = 1 to n = 2 will be

(1) $2.816\times10^{-7}m$ (2) $6.500\times10^{-7}m$

(3) $8.500\times10^{-7}m$ (4) $1.214\times10^{-7}m$

$\Delta E = 2.178\times10^{-18}\left(1-\dfrac{1}{4}\right) = \dfrac{2\times10^{-25}}{\lambda}$

$\lambda = \dfrac{4\times2\times10^{-25}}{2.178\times10^{-18}\times3} = 1.2\times10^{-7}m$

27. The kinetic energy of an electron in the second orbit of a hydrogen atom is (a_o = Bohr Radius)

(1) $\dfrac{h}{4\pi^2 m{a_o}^2}$ (2) $\dfrac{h}{16\pi^2 m{a_o}^2}$

(3) $\dfrac{h}{32\pi^2 m{a_o}^2}$ (4) $\dfrac{h}{64\pi^2 m{a_o}^2}$

$\dfrac{h^2}{32\pi^2 ma_0}$

28. The angular momentum of electron in Bohr's orbit is J. What will be the Kinetic energy of that Bohr's orbit

(1) $\dfrac{Jv}{2r}$ (2) $\dfrac{Jv}{r}$ (3) $\dfrac{2Jv}{r}$ (4) $\dfrac{J^2}{2\pi}$

$mvr = J$

$v = \dfrac{J}{mr}$

$K.E. = \dfrac{1}{2}mv^2$

$= \dfrac{1}{2}m\left(\dfrac{J}{mr}\right)^2 = \dfrac{1}{2}.\dfrac{J^2}{mr^2}$

or $m = \dfrac{J}{vr}$

$K.E. = \dfrac{1}{2}mv^2 = \dfrac{1}{2}\dfrac{J}{vr}\times v^2$

$$= \frac{Jv}{2r}$$

29. The ionization energy of He^+ is 19.6 × 10^{-18} J per atom. The energy of the first stationary state of Li^{2+} is

(1) 19.6 × 10^{-18} J (2) 5 × 10^{-18} J
(3) 4.41 × 10^{-17} J (4) 4.41 × 10^{-18} J

$$E_H = -\frac{19.6\times10^{-18}}{(2)^2}$$

$$E_{Li^{2+}} = -\frac{19.6\times10^{-18}}{(2)^2}\times\frac{(3)^2}{(1)^2}$$

$$= -4.41\times10^{-17}\,J$$

30. The ionization energy of hydrogen atom in the ground state is x kJ. The energy required for an electron to jump for 2nd orbit to 3rd orbit is

(1) $\frac{5x}{36}$ (2) 5x (3) 7.2x (4) $\frac{x}{6}$

$$E = -\frac{x}{n^2}$$

$$E_3 = -\frac{x}{9}$$

$$E_2 = -\frac{x}{4}$$

$$\Delta E = \left(-\frac{x}{9}\right) - \left(\frac{x}{4}\right) = \frac{5x}{36}$$

ATOMIC SPECTRUM

31. What transition in the Li^{2+} spectrum would have the same wavelength as the Balmer transition n= 4 to n= 2 of He^+ spectrum

(1) n= 6 to n= 2 (2) n= 6 to n= 3 (3) n= 4 to n= 2 (4) n= 4 to n= 3

$$\frac{\frac{1}{\lambda_H} = R\left(\frac{1}{3^2}-\frac{1}{4^2}\right)}{\frac{1}{\lambda_{He^+}} = R\times4\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)}$$

$$4\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right) = \frac{7}{144}$$

$$\frac{1}{n_1^2}-\frac{1}{n_2^2} = \frac{7}{576}$$

$$\therefore\ n_1 = 6$$

$$n_2 = 8$$

32. The wave number of first line of Balmer series of hydrogen is 15200 cm^{-1}. The wave number of the first line of same series in Li^{2+} ion is

(1) 15200 cm^{-1} (2) 60800 cm^{-1}
(3) 76000 cm^{-1} (4) 136800 cm^{-1}

$$\bar{\nu}_{Li^{2+}} = z^2\bar{\nu}_H = 15200\times 9$$
$$= 136800\, cm^{-1}$$

33. The emission spectrum of He^+ ion is the consequence of transition of electrons from orbit n_2 to orbit n_1. Given that $2n_2 + 3n_1 = 18$ and $2n_2 - 3n_1 = 6$, then what will be the maximum number of spectral lines in atomic spectrum when electrons transit from n_2 to orbit n_1?

(1) 10 (2) 15 (3) 20 (4) 21

$2n_2 + 3n_1 = 18$ (1)

$+2n_2 - 3n_1 = 6$ (2)

$4n_2 = 24$

$n_2 = 6$

$2 \times 6 - 3n_1 = 6$

$3n_1 = 6$

$n_1 = 2$

No. of spectral lines = 10

34. Find the value of wave number in terms of Rydberg's constant, when transition of electron takes place between two levels of He^+ ion whose sum is 4 and difference is 2.

(1) $\frac{8R}{9}$ (2) $\frac{32R}{9}$
(3) $\frac{3R}{4}$ (4) None of these

$n_1 + n_2 = 4$

$n_2 - n_1 = 2$

$n_2 = 3, n_1 = 1$

$$\bar{\nu} = R(2)^2\left[\frac{1}{1^2} - \frac{1}{3^2}\right] = 4R\times\frac{8}{9}$$
$$= \frac{32R}{9}$$

35. The angular momentum of an electron in a Bohr's orbit of hydrogen atom is $\frac{2h}{\pi}$. The wavelength of spectral line emitted when the electron falls from this level to next lower level is

(1) $\frac{9R_H}{16\times 25}$ Å (2) $\frac{16\times 25}{9R_H}$ Å (3) $\frac{7R_H}{144}$ Å (4) $\frac{144}{7R_H}$ Å

$$\frac{nh}{2\pi} = \frac{2n}{\pi} \Rightarrow n = 4$$

$$\frac{1}{\lambda} = R\left[\frac{1}{3^2} - \frac{1}{4^2}\right] = R\left[\frac{1}{9} - \frac{1}{16}\right]$$

$$\lambda = \frac{144}{7R}$$

36. When an electron makes a transition from $(n + 1)$ state to nth state, the frequency of emitted radiations is related to n according to $(n >> 1)$:

(1) $v = \frac{2cRZ^2}{n^3}$ (2) $v = \frac{cRZ^2}{n^4}$ (3) $v = \frac{cRZ^2}{n^2}$ (4) $v = \frac{2cRZ^2}{n^2}$

$$\frac{1}{\lambda} = RZ^2\left(\frac{1}{n^2} - \frac{1}{(n+1)^2}\right)$$

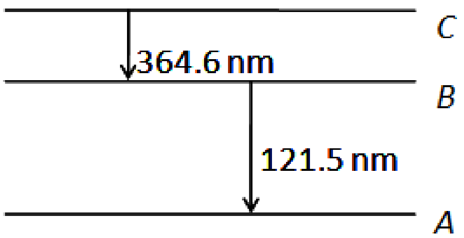
$$= RZ^2\left[\frac{(n+1) - n^2}{n^2(n+1)^2}\right]$$

$$= RZ^2\left[\frac{2n}{n^4}\right] \qquad (n >> 1)$$

$$\frac{v}{c} = \frac{2RZ^2}{n^3}$$

or $v = \frac{2cRZ^2}{n^3}$

37. Three atomic states of a hydrogen like atom are shown in the figure. The transition from C to B yields a photon of wavelength 364.6 nm and the transition from B to A yields a photon of wavelength 121.5 nm, Then the transition from C to A will yield a photon of wavelength.



(1) 91.2 nm (2) 243.1 nm

(3) 486.1nm (4) None of these

$$\lambda_{c-A} = \frac{\lambda_1\lambda_2}{\lambda_1 + \lambda_2} \qquad \lambda_1 = 364.6\,nm,\ \lambda_2 = 121.5\,nm$$

$$= \frac{364.6 \times 121.5}{364.6 + 121.5}$$

$$= \frac{364.6 \times 121.5}{486.1} = 91.13\text{ nm}$$

38. Which of the following transitions have the wave number ratio 108:7 in atomic spectra of hydrogen

(1) First Lyman and First Brackett
(2) First and second Lyman
(3) First Lyman and First Balmer
(4) First Lyman and First Paschen

First Lyman series

$$\bar{v} = R\left(\frac{1}{1}-\frac{1}{4}\right) = \frac{3}{4}R$$

First Paschen series

$$\bar{v} = R\left(\frac{1}{9}-\frac{1}{16}\right)$$

$$= R\frac{7}{144}$$

$$\frac{\bar{v}_{Lyman}}{\bar{v}_{Paschen}} = \frac{\frac{3}{4}}{\frac{7}{144}} = \frac{3\times 144}{28} = \frac{108}{7}$$

39. Which electronic transition in a hydrogen atom, starting from the orbit $n = 7$, will produce infrared light of wavelength 2170 nm?

(1) $n = 7$ to $n = 6$
(2) $n = 7$ to $n = 5$
(3) $n = 7$ to $n = 4$
(4) $n = 7$ to $n = 3$

$$\frac{1}{\lambda} = R\left(\frac{1}{n^2}-\frac{1}{49}\right)$$

$$\frac{1}{2170\times 10^{-7}} = 109677\left(\frac{49-n^2}{49n^2}\right)$$

$$49n^2 = 109677\times 2170\times 10^{-2}(49-n^2)$$

n = 4

40. The energy of a I, II and III energy levels of a certain atom are E, 4E/3 and 2E respectively. A photon of wavelength λ is emitted during a transition from III to I. What will be the wavelength of emission for transition II to I?

(1) $\frac{\lambda}{2}$
(2) λ
(3) 2λ
(4) 3λ

$$E_{III} - E_I = 2E - E = E$$

$$\frac{hc}{\lambda} = E \quad \text{or} \quad \lambda = \frac{hc}{E}$$

$$E_{II} - E_I = \frac{4E}{3} - E = \frac{E}{3} = \frac{hc}{3\lambda}$$

$$\frac{hc}{\lambda'} = \frac{hc}{3\lambda}$$

or $\lambda' = 3\lambda$

41. A hydrogen atom sample in the ground state is excited by monochromatic radiation of wavelength $\lambda\,\mathring{A}$ The resulting spectrum consists of maximum 15 different lines. What is the wavelength λ ?

(1) $937.3\,\mathring{A}$ (2) $1025\,\mathring{A}$

(3) $1236\,\mathring{A}$ (4) None of these

$$\frac{n(n-1)}{2}=15$$

$$n^2-n=30$$

$$n^2-n-30=0$$

$$n^2-6n+5n-30=0$$

$$n(n-6)+5(n-6)=0$$

$$n = 6$$

$$\frac{1}{\lambda}=109677\left(\frac{1}{1}-\frac{1}{36}\right)$$

$$\lambda=937.3\mathring{A}$$

42. When electrons are de-exciting from nth orbit of hydrogen atoms, 15 spectral lines are formed. The shortest wavelength among these will be

(1) $\frac{11}{900}R$ (2) $\frac{900}{11R}$ (3) $\frac{35}{36R}$ (4) $\frac{36}{35R}$

$$\frac{n(n-1)}{2}=15 \Rightarrow n=6$$

$$\frac{1}{\lambda}=R\left[\frac{1}{1^2}-\frac{1}{6^2}\right]=R\left[\frac{1}{1}-\frac{1}{36}\right]$$

$$\lambda=\frac{36}{35R}$$

43. Which of the following transitions of an electron in a H–atom would emit a photon of minimum wavelength?

(1) 8 to 3 (2) 6 to 1 (3) 2 to 1 (4) 7 to 5

$\Delta E \uparrow \quad \lambda \downarrow$

44. In a discharge tube, there are only two hydrogen atoms. If the electrons in both atoms are de-exciting from 4th orbit, the minimum and maximum number of spectral lines should respectively be

(1) 1, 4 (2) 4, 1 (3) 3, 4 (4) 1, 6

For maximum spectral line,

1st atom	2nd atom
$4\rightarrow3\rightarrow2\rightarrow1$	$4\rightarrow3\rightarrow1$
	or
	$4\rightarrow2\rightarrow1$
	or
	$4\rightarrow1$

Maximum lines = 3+1 = 4

Minimum line = 1 ($4 \rightarrow 1$ transition in both atoms)

45. If the electron of Hydrogen atom is excited to 4th excited state, then the total spectral lines falling in Paschen series are equal to:

(1) 2 (2) 10 (3) 3 (4) 4

$4 \rightarrow 2$ & $3 \rightarrow 2$

de-BROGLIE DUAL NATURE PRINCIPLE

46. Wavelength associated with Virar-F local train having mass 100×10^3 Kg moving with the speed of 23.76 kms/hr is: (plank's constant $=6.6\times 10^{-34}$ Js)

(1) $10^{-31} A^o$ (2) $10^{-35} A^o$ (3) $10^{-29} A^o$ (4) $10^{-40} A^o$

$$\Delta x \times \Delta v = \frac{h}{4\pi m}$$

$$10^{-10} \times \Delta v = \frac{6.626 \times 10^{-34}}{4 \times 3.14 \times 0.21}$$

$$\Delta v = 2.5 \times 10^{-24} \text{ m/s}$$

47. If the radius of first Bohr orbit is x, then de Broglie wavelength of electron in 3rd orbit is nearly.

(1) $2\pi x$ (2) $6\pi x$ (3) 9x (4) None

$$n\lambda = 2\pi r_3$$

$$3\lambda = 2\pi \times x \times 9$$

$$\lambda = 6\pi x$$

48. An electron, practically at rest is initially accelerated through a potential difference of 100V has a de Broglie wavelength $= \lambda_1 A^0$. It then retarded through 19V has a de Broglie wavelength $= \lambda_2 A^0$. A further retardation through 32V has de Broglie wavelength $= \lambda_3 A^0$.

What is the value of $\frac{\lambda_3 - \lambda_2}{\lambda_1}$

(1) 20/41 (2) 10/63 (3) 20/63 (4) 10/41

Principal quantum no. – size

Azimuthal quantum no. – shape

Magnetic quantum no. – orientation

49. A particle moving with a certain velocity has a de-Broglie wavelength of $1\,A^o$. If the particle B has mass 25% of that A and velocity 75% of that of A, the de-Broglie wavelength of the B will be

(1) $1\,A^o$ (2) $5.3\,A^o$ (3) $3\,A^o$ (4) $2.65\,A^o$

$$\frac{\lambda_A}{\lambda_B} = \frac{m_B v_B}{m_A v_A} = \frac{0.25 m_A \times 0.75 v_A}{m_A v_A}$$

$$\lambda_A = 0.1875 \lambda_B$$

or $\lambda_B = 5.3\text{Å}$

50. Calculate the De-Broglie wave length of the electron in the ground state of hydrogen atom, given that its kinetic energy is 13.6 eV

(1) $3.328\,A^o$ (2) $2\,A^o$ (3) $1.328\,A^o$ (4) $4\,A^o$

$$\lambda = \sqrt{\frac{150}{13.6}} = 3.32\,\overset{o}{A}$$

51. An electron in a hydrogen atom in its ground state absorbs1.5 times as much energy as the minimum required for it to escape from the atom what is the wavelength of the emmited electron

(1) $4.7\,A^o$ (2) $9.4\,A^o$ (3) $2.35\,A^o$ (4) $18.8\,A^o$

$$K.E. = (1.5\times 13.6) - 13.6 = 6.8\,\overset{o}{A}$$

$$\lambda = \sqrt{\frac{150}{6.8}} = 4.69\,\overset{o}{A}$$

UNCERTAINTY HEISENBERG PRINCIPLE

52. A mass of cricket ball is 0.21 kg. If the order of uncertainty in position is 100pm then uncertainty in its velocity is:

(1) 3.5×10^{-24} m/sec (2) 6.02×10^{-23} m/sec
(3) 6.602×10^{-27} m/sec (4) 2.5×10^{-24} m/sec

$$\Delta V = \frac{6.62\times 10^{-34}}{4\times 3.14\times 0.21\times 100\times 10^{-12}}$$

$$= 2.5\times 10^{-24}\,m/sec$$

53. Uncertainty in position and momentum are equal. Uncertainty in velocity is:

(1) $\sqrt{\frac{h}{\pi}}$ (2) $\frac{h}{2\pi}$ (3) $\frac{1}{2m}\sqrt{\frac{h}{\pi}}$ (4) none

$$\Delta x = \Delta P$$

$$\Delta \times \Delta P \geq \frac{h}{4\pi}$$

$$(\Delta P)^2 \geq \frac{h}{4\pi}$$

$$m^2(\Delta V)^2 \geq \frac{h}{4\pi} \Rightarrow \Delta V \geq \frac{1}{2m}\sqrt{\frac{h}{\pi}}$$

54. A ball of mass 200 g is moving with a velocity of $10ms^{-1}$. If the error in measurement of velocity is 0.1%, the uncertainty in its position is:

(1) 3.3×10^{-3} m (2) 3.3×10^{-27} m
(3) 5.3×10^{-25} m (4) 2.64×10^{-32} m

$$\Delta x \geq \frac{6.62\times 10^{-34}}{4\times 3.14\times 0.2\times 10\times \frac{0.1}{10}}$$

$$= 2.63\times 10^{-32}\,m$$

55. In an atom, an electron is moving with a speed of 600 m/s with an accuracy of 0.005% certainty with which the position of the electron can be located is

($h = 6.6\times10^{-34}\,kgm^2s^{-1}$, Mass of electron, $e_m = 9.1\times10^{-31}$ kg)

(1) 1.52×10^{-4}m
(2) 5.10×10^{-3}m
(3) 1.92×10^{-3}m
(4) 3.84×10^{-3}m

$$\Delta x \geq \frac{6.62\times10^{-34}}{4\times3.14\times9.1\times10^{-31}\times600\times\frac{0.005}{100}} = 1.93\times10^{-3}\,m$$

PHOTOELECTRIC EFFECT

56. If λ_0 and λ be the threshold wavelength and wavelength of incident light, the velocity of photoelectron ejected from the metal surface is

(1) $\sqrt{\frac{2h}{m}(\lambda_0-\lambda)}$
(2) $\sqrt{\frac{2hc}{m}(\lambda_0-\lambda)}$
(3) $\sqrt{\frac{2hc}{m}\left(\frac{\lambda_0-\lambda}{\lambda\lambda_0}\right)}$
(4) $\sqrt{\frac{2h}{m}\left(\frac{1}{\lambda_0}-\frac{1}{\lambda}\right)}$

$$\frac{1}{2}mv^2 = \frac{hC}{\lambda} - \frac{hC}{\lambda_o}$$

$$v = \sqrt{\frac{hC}{m}\left(\frac{1}{\lambda}-\frac{1}{\lambda}\right)} = \sqrt{\frac{2hC}{m}\left(\frac{\lambda_0-\lambda}{\lambda\lambda_o}\right)}$$

57. The kinetic energy of the electron emitted when light of frequency 3.5×10^{15} Hz falls on a metal surface having threshold frequency, 1.5×10^{15} Hz is (h = 6.6×10^{-34} J sec):

(1) 1.32×10^{-18} J
(2) 3.3×10^{-18} J
(3) 6.6×10^{-19} J
(4) 1.98×10^{-19}J

$$K.E. = 6.62\times10^{-34}\left(3.5\times10^{15} - 15\times10^{15}\right)$$

$$= 1.324\times10^{-18}\,J$$

58. When photons of energy 4.25 eV strike the surface of a metal A. The ejected photo electron shave maximum kinetic energy (T_A (expressed in eV) and de-Broglie wavelength (λ_A) The max kinetic energy of photoelectrons liberated from another Metal B by photons of energy 4.2 eV is T_B. Where T_B= (T_A–1.5). If De-Broglie wave length of these photoelectrons λ_B ($\lambda_B = 2\lambda_A$), then which of the following is not correct

(1) The work function of A is 2.25 eV.
(2) The work function of B is 3.7 eV
(3) T_A = 2.0 eV
(4) T_B =0 .75 eV

$$\lambda_B = 2\lambda_A \Rightarrow \sqrt{\frac{15^0}{T_B}} = 2\sqrt{\frac{150}{T_A}} \Rightarrow T_A = 4T_B$$

$$T_B = T_A - 1.5$$

$$T_B = 4T_B - 1.5 \Rightarrow 3T_B = 1.5$$

$$T_B = 0.5eV \;\&\; T_A = 2eV$$

$$T_B = E_B = \phi_B \Rightarrow \phi_B = E_B - T_B = 4.2 - 0.5$$

$$= 3.7eV$$

$$\phi_A = E_A - T_A = 4.25 - 2 = 2.25eV$$

59. Work function W_A for a photoelectric material A is 2 eV & W_B for another photoelectric material B is 4 eV. If the photons of energy E_A strike with surface of A the ejected photoelectrons have minimum de-Broglie wavelength λ_A and photons of energy EB strike the surface of B, the ejected photoelectrons have minimum de-Broglie wavelength λ_B. Where E_B= (E_A+0.5) eV and $\lambda_B = 2\lambda_A$, V_A and V_B are respective stopping potentials then which of the following is not correct

(1) $E_A = 4$ eV
(2) $E_A = 4.5$ eV
(3) $V_A = 2$ Volts
(4) $V_B = 0.5$ Volts

$\lambda_B = 2\lambda_A \Rightarrow T_A = 4T_B$

$E_A - \phi_A = 4(E_B - \phi_B)$

$E_A - 2 = 4(E_B - 4) \Rightarrow 4EB - EA = 14$

$E_B - E_A = 0.5 \Rightarrow 3EB = 13.5 \Rightarrow EB = 4.5$

$EA = 4eV \qquad T_A = 4 - 2 = 2eV \Rightarrow VA = 2A$

QUANTUM MODEL

60. Total number of electrons in any orbit is:

(1) $\sum_{l=1}^{l=n} 2(2l+1)$
(2) $\sum_{l=1}^{l=n-1} 2(2l+1)$
(3) $\sum_{l=0}^{l=n+1} 2(2l+1)$
(4) $\sum_{l=0}^{l=n-1} 2(2l+1)$

Total no. of electrons in a subshell = $2(2\ell+1)$

In an orbit ℓ varies from 0 to n – 1

61. The subshell that arises after *f* is called the *g* subshell. How many electrons may occupy the *g* subshell?

(1) 9
(2) 7
(3) 5
(4) 18

g- subshell has n orbitals

$\therefore$ 18 e^{-s}

62. If the nodes at infinity are not neglected, then what is the total number of radial and angular nodes of 5f-orbitals?

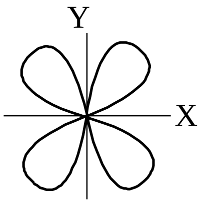
(1) 4
(2) 3
(3) 5
(4) infinity

Total no. of nodes including infinity

= (n – 1) + 1 = n = 5

63. Which of the d-orbital lies in the xy-plane

(1) d_{XZ} only
(2) d_{XY} only
(3) $d_{X^2-Y^2}$ only
(4) d_{XY} and $d_{X^2-Y^2}$



d_{xy}

64. Given, (i) n = 5, m_l = +1; (ii) n = 2, l = 1, m_l = –1, m_s = –1/2
The maximum number of electron(s) in an atom that can have the quantum numbers as given in (i) and (ii) are respectively
(1) 25 and 1 (2) 8 and 1 (3) 2 and 4 (4) 4 and 1
n = 5, m = + 1
i.e. 1 orbital of P, d, f, g each
no of electrons = $4\times2=8$
$n=2,\ \ell=1,\ m=-1,\ s=-\frac{1}{2}$
i.e. 1 electron.

65. The orbital angular momentum of a P electron is given as
(1) $\sqrt{3}\frac{h}{2\pi}$ (2) $\sqrt{3/2}\,\frac{h}{2\pi}$ (3) $\frac{h}{2\pi}$ (4) $\frac{h}{\sqrt{2}\pi}$
$$\sqrt{\ell(\ell+1)}\frac{h}{2\pi}=\sqrt{1(1+1)}\frac{h}{2\pi}=\frac{\sqrt{2}h}{2\pi}$$

ELECTRONIC CONFIGURATION

66. Which of the following is having the maximum number of unpaired electrons?
(1) Mg^{2+} (2) Ti^{3+} (3) V^{3+} (4) Fe^{2+}
$Mg^{2+}\,[Ne](n=0)$
$Ti^{3+}:[Ar]4s^o3d^1(n=1)$
$V^{3+}:[Ar]4s^o3d^2(n=2)$
$Fe^{2+}:[Ar]4s^o3d^6(n=4)$

67. The value of the magnetic moment of a particular ion is 2.83 Bohr magneton. The ion is
(1) Fe^{2+} (2) Ni^{2+} (3) Mn^{2+} (4) Co^{3+}
$\sqrt{n(n+2)}=2.83=\sqrt{8}\Rightarrow n=2$
$Ni^{2+}:[Ap]4s^23d^8(n=2)$

68. A compound of vanadium has a magnetic moment (μ) of 1.73 BM. If the vanadium ion in the compound is present as V^{x+}, then, the value of x is?
(1) 1 (2) 2 (3) 3 (4) 4
$1.73=\sqrt{3}=\sqrt{n(n+2)}\Rightarrow n=1$
$V=[Ar]4s^23d^3(n=3)$
$V^{4+}=[Ar]4s^03d^1(n=1)$

69. If an ion of $_{25}Mn$ has a magnetic moment of 3.873 B.M. Then Mn is in which state.
(1) + 2 (2) + 3 (3) + 4 (4) + 5
$3.873=\sqrt{15}=\sqrt{n(n+2)}\Rightarrow n=3$
$Mn=[Ar]4s^23d^5(n=5)$
$Mn^{4+}=[Ar]4s^03d^3(n=3)$

70. Which of the following ions has the maximum magnetic moment?

(1) Mn^{+2} (2) Fe^{+2} (3) Ti^{+2} (4) Cr^{+2}

$Mn^{2+} = [Ar]4s^0 3d^5 (n = 5)$

$Fe^{2+} = [Ar]4s^o 3d^6 (n = 4)$

$Ti^{2+} = [Ar]4s^0 3d^2 (n = 2)$

$Cr^{2+} = [Ar]4s^0 3d^4 (n = 4)$

71. If Hund's rule is followed, magnetic moment of Fe^{2+}, Mn^+ and Cr will be in order

(1) $Fe^{2+} < Mn^+ < Cr$ (2) $Fe^{2+} < Mn^+ = Cr$

(3) $Fe^{2+} = Mn^+ < Cr$ (4) $Mn^+ = Cr < Fe^{2+}$

$Fe^{2+} = [Ar]us^0 3d^6 (n = 4)$

$Mn^+ = [Ar]us^1 3d^5 (n = 6)$

$Cr = [Ar]us^1 3d^5 (n = 6)$

72. Consider the ground state of Cu atom (z = 29). The number of electrons with the azimuthal quantum numbers *l* = 1 and 2 are respectively

(1) 16 and 6 (2) 12 and 10 (3) 12 and 9 (4) 16 and 5

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$

Total p electrons = 6+6=12

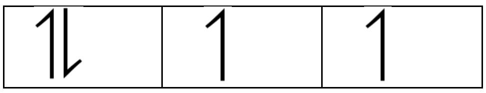
Total d electrons = 10

73. The total spin and magnetic moment for oxygen atom are

(1) $\pm 1, \sqrt{8}$ BM (2) ± 2, 6.93 BM

(3) $\pm 1, \sqrt{15}$ BM (4) $\pm 2, \sqrt{48}$ BM

$1s^2\ 2s^2\ 2p^4$



n = 2

$$\text{Total spin} = \pm \frac{1}{2} \times 2$$

$$= \pm 1$$

$$\text{Magnetic moment } = \sqrt{2(2+2)}$$

$$= \sqrt{8}$$

74. If the number of orbitals of a particular type were (3l + 1), but spin quantum numbers only + ½ and – ½, then a d-type orbital will contain a maximum of electrons.

(1) 10 (2) 14 (3) 2 (4) 5

An orbital can occupy maximum 2 electrons.

75. The number of electrons in the ground state of Fe atom whose l+m is equal to 0

(1) 13 (2) 10 (3) 9 (4) 11

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$

$\ell = 0, m = 0$

S orbitals = 8 electrons

$\ell = 1, m = -1$

1 orbital of each 2p, 3p
=4 electrons
$\ell = 2, m = -2$
1 orbital of 3d
= 1 or 2 electrons
no. of electrons = $8+4+1=13$
or
8+4+2=14

ASSERTION AND REASON

Read the assertion and reason carefully to mark the correct option out of the options given below :
(1) If both assertion and reason are true and the reason is the correct explanation of the assertion.
(2) If both assertion and reason are true but reason is not the correct explanation of the assertion.
(3) If assertion is true but reason is false.
(4) If the assertion and reason both are false.
(5) If assertion is false but reason is true.

1. Assertion : Threshold frequency is a characteristic for a metal.
Reason : Threshold frequency is a maximum frequency required for the ejection of electron from the metal surface.
(3)

2. Assertion : The radius of the first orbit of hydrogen atom is 0.529Å.
Reason : Radius for each circular orbit $(r_n) = 0.529$Å (n^2/Z), where n = 1,2,3 and Z = atomic number.
(1)

3. Assertion : $3d_{z^2}$ orbital is spherically symmetrical.
Reason : $3d_{z^2}$ orbital is the only d-orbital which is spherical in shape.
(4)

4. Assertion : Spin quantum number can have the value +1/2 or –1/2.
Reason : (+) sign here signifies the wave function.
(3)

5. Assertion : Total number of orbitals associated with principal quantum number n = 3 is 6.
Reason : Number of orbitals in a shell equals to 2n.
(4)

6. Assertion : Splitting of the spectral lines in the presence of magnetic field is known as stark effect.
Reason : Line spectrum is simplest for hydrogen atom.
(5)

7. Assertion : Thomson's atomic model is known as 'raisin pudding' model.
Reason : The atom is visualized as a pudding of positive charge with electrons (raisins) embedded in it.
(1)

8. Assertion : The transition of electrons $n_3 \to n_2$ in H atom will emit greater energy than $n_4 \to n_3$.

Reason : n_3 and n_2 are closer to nucleus than n_4.

(1)

9. Assertion : Cathode rays are a stream of α-particles.

Reason : They are generated under high pressure and high voltage.

(4)

PREVIOUS YEARS QUESTIONS

1. The measurement of the electron position is associated with an uncertainly in momentum, which is equal to $1\times10^{-18}\,g\,cm\,s^{-1}$. The uncertainly in electron velocity is (Mass of an electron $9\times10^{-28}\,g$) **[CBSE AIPMT 2008]**

(1) $1\times10^{9}\,cm\,s^{-1}$ (2) $1\times10^{6}\,cm\,s^{-1}$ (3) $1\times10^{5}\,cm\,s^{-1}$ (4) $1\times10^{11}\,cm\,s^{-1}$

(1)

Given $\Delta p = 1\times10^{-18}\,g\,cm\,s^{-1}$ (uncertainly in momentum)

Mass = $9\times10^{-28}\,g$

$\Delta p = m\Delta v$

$1\times10^{-18} = 9\times10^{-28}\,g$

(uncertainly in velocity)

$\Delta v = 1\times10^{9}\,cm\,s^{-1}$

2. Which is the correct order increasing energy of the listed orbitals in the atom of titanium? (At. no. Z = 22) **(CBSE AIPMT 2015)**

(1) 3s 3p 3d 4s (2) 3s 3p 4s 3d (3) 3s 4s 3p 3d (4) 4s 3s 3p 3d

(1)

According to Aufbau rule

3s < 3p < 4s < 3d

3. The number of d-electrons in Fe^{2+}(Z = 26) is not equal to the number of electrons in which one of the following? **(AIPMT 2015)**

(1) p - electrons in CI (Z = 17)

(2) d - electrons in Fe(Z = 26)

(3) p - electrons in Ne (Z = 10)

(4) s - electrons in Mg (Z = 12)

(1)

Electronic configuration of Fe^{2+} is $[Ar]3d^6\,4s^0$.

$\therefore$ number of electrons = 6

Mg $-1s^2 2s^2 2p^6 3s^2$ (6s electrons)

It matches with the 6d electrons of Fe^{2+}

Cl $-1s^2 2s^2 2p^6 3s^2 3p^5$ (11p electrons)

It does not match with the 6d electrons of Fe^{2+}

Fe– $[Ar]3d^6 4s^2$ (6d electrons)

It matches with the 6d electrons of Fe^{2+}

Hence, Cl has 11p electrons which does not matches in number with 6d electrons of Fe^{2+}.

4. The angular momentum of electron in 'd' orbital is equal to: **[CBSE AIPMT 2015]**

(1) $\sqrt{2}\hbar$ (2) $2\sqrt{3}\hbar$ (3) $0\hbar$ (4) $\sqrt{6}\hbar$

(4)

Angular momentum of electrons in d-orbital is

$=\sqrt{l(l+1)}\frac{h}{2\pi}$; for d – orbital, l = 2

$=\sqrt{2(2+1)}$ $\left(\because \hbar=\frac{h}{2\pi}\right)$

$=\sqrt{6}\hbar$

5. Calculate the energy in joule corresponding to light of wavelength 45 nm: (Planck's constant $h=6.63\times10^{-34}$ Js; ; speed of light $c=3\times10^{8}$) **(AIPMT 2014)**

(1) 4.42×10^{-15} (2) 4.42×10^{-18} (3) 6.67×10^{15} (4) 6.67×10^{11}

(2)

The wavelength of light is related to its energy by the equation, $E=\frac{hc}{\lambda}(E=hv)$]

Given, $\lambda=45nm=45\times10^{-9}m$

$[\because 1nm=10^{-9}m]$

Hence, $E=\frac{6.63\times10^{-34}Js\times3\times10^{8}ms^{-1}}{45\times10^{-9}m}$

$=4.42\times10^{-18}J$

Hence, the energy corresponds to light of wavelength 45nm is 4.42×10^{-18}J.

6. The value of Planck's constant is 6.63×10^{-34}Js. The speed of light is $3\times10^{17}ms^{-1}$. Which value is closest to the wavelength in nanometer of a quantum of light with frequency of $6\times10^{15}s^{-1}$? **[NEET-UG 2013]**

(1) 75 (2) 10 (3) 25 (4) 50

(4)

Given, Planck's constant,

$h=6.63\times10^{-34}Js$

Speed of light, $c=3\times10^{17}nms^{-1}$

Frequency of quantum light

$v=6\times10^{15}s^{-1}$

Wavelength, $\lambda=?$

We know that, $v=\frac{c}{\lambda}$ or $\lambda=\frac{c}{v}$

$=\frac{3\times10^{17}}{6\times10^{15}}$

$=0.5\times10^{2}nm=50nm$

7. What is the maximum numbers of electrons that can be associated with the following set of quantum numbers? **[NEET-UG 2013]**

n = 3, *l* = 1 and m = –1

(1) 2 (2) 10 (3) 6 (4) 4

(1)

The orbital of the electron having $n=3$, $l=1$ and $m=-1$ is $3p_z$ (as nl_m) and an orbital can have a maximum number of two electrons with opposite spins.

$\therefore$ $3p_z$ orbital contains only two electrons or only 2 electrons are associated with $n=3, l=1, m=-1$.

8. The energy absorbed by each molecule (A_2) of substance is 4.4×10^{-19} J and bond energy per molecule is 4.0×10^{-19} J. The kinetic energy of the molecule per atom will be **[CBSE AIPMT 2009]**

(1) 2.0×10^{-20} J (2) 2.2×10^{-19} J (3) 2.0×10^{-19} J (4) 4.0×10^{-20} J

(1)

Kinetic energy (KE) of molecule
=energy absorbed by molecule
–bond energy per molecule

$=(4.4\times10^{-19})-(4.0\times10^{-19})$ J

$=0.4\times10^{-19}$ J

KE per atom

$=\frac{0.4\times10^{-19}}{2}$ J

$=2.0\times10^{-20}$ J

9. 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 **(CBSE AIPMT 2011)**

(1) $\lambda_1=\frac{1}{2}\lambda_2$ (2) $\lambda_1=\lambda_2$ (3) $\lambda_1=2\lambda_2$ (4) $\lambda_1=4\lambda_2$

(3)

$E_1=25\text{eV}, E_2=50\text{eV}$

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

or $\frac{E_1}{E_2}=\frac{\lambda_2}{\lambda_1}$

or $\frac{25}{50}=\frac{\lambda_2}{\lambda 1}$

or $\lambda_1=2\lambda_2$

10. Which of the following is not permissible arrangement of electrons in an atom? **[CBSE AIPMT 2009]**

(1) n = 4, l = 0, m = 0, s = –1/2
(2) n = 5, l = 3, m = 0, s = +1/2
(3) n = 3, l = 2, m = –3, s = –1/2
(4) n = 3, l = 2, m = –2, s = –1/2

(3)

If $n=3$,

$l = 0$ to $(3-1) = 0, 1, 2$

$m = -l$ to $+l = -2, -1, 0, +1, +2$

$s = \pm\frac{1}{2}$

Therefore, option (c) is not a permissible set of quantum numbers.

11. Maximum number of electrons in a subshell of an atom is determined by the following **(CBSE AIPMT 2009)**

(1) $4\ell+2$ (2) $2\ell+1$ (3) $4\ell-2$ (4) $2n^2$

(1)

Total number of subshells $= (2l+1)$

$\therefore$ Maximum number of electrons in the subshell

$= 2(2l+1) = 4l+2$

14. Consider the following sets of quantum numbers **(CBSE AIPMT 2007)**

	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?

(1) (ii), (iii) and (iv) (2) (i), (ii), (iii) and (iv) (3) (ii), (iv) and (v) (4) (i) and (iii).

(3)

The value of l varies from 0 to $(n-1)$ and the value of m varies from $-l$ to $+l$ through zero.

The value of 's' $\pm\frac{1}{2}$ which signifies the spin of electron. The correct sets of quantum number are following

	n	l	m	s
(ii)	2	1	1	$-\frac{1}{2}$
(iv)	1	0	0	$-\frac{1}{2}$
(v)	3	2	2	$+\frac{1}{2}$

15. The orientation of an atomic orbital is governed by **[CBSE AIPMT 2006]**

(1) azimuthal quantum number (2) spin quantum number

(3) magnetic quantum number (4) principal quantum number

(3)

The orientation of an atomic orbital is governed by magnetic quantum number.

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 **(CBSE AIPMT 2005)**

(1) –41 kJ mol^{-1} (2) –1312 kJ mol^{-1} (3) –164 kJ mol^{-1} (4) –82 kJ mol^{-1}

(4)

The energy of second Bohr orbit of hydrogen atom (E_2) is –328 kJ mol^{-1}

$$En = -\frac{1312}{n^2}\,kJ\,mol^{-1}$$

$$\therefore E_2 = -\frac{1312}{2^2}\,kJ\,mol^{-1}$$

If $n = 4$

$$\therefore E_4 = -\frac{1312}{4^2}\,kJ\,mol^{-1}$$

$$= -82\,kJ\,mol^{-1}$$

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 $H = 2.18\times10^{-18}\,J\ atom^{-1}$ and $h = 6.625\times10^{-34}\,Js$) **[CBSE AIPMT 2004]**

(1) $1.54\times10^{15}s^{-1}$ (2) $1.03\times10^{15}s^{-1}$ (3) $3.08\times10^{15}s^{-1}$ (4) $2.00\times10^{15}s^{-1}$

(3)

Ionization energy of H

$$= 2.18\times10^{-18}\,J\ atom^{-1}$$

$\therefore E_1$ (Energy of 1st orbit of H-atom)

$$= -2.18\times10^{-18}\,J\ atom^{-1}$$

$$\therefore \quad E_n = \frac{-2.18\times10^{-18}}{n^2}\,J\,atom^{-1}$$

Z = 1 for H-atom

$$\Delta E = E_4 - E_1$$

$$= \frac{-2.18\times10^{-18}}{4^2} - \frac{-2.18\times10^{-18}}{1^2}$$

$$= -2.18\times10^{-18}\times\left[\frac{1}{4^2}-\frac{1}{1^2}\right]$$

$$\Delta E = -2.18\times10^{-18}\times-\frac{15}{16}$$

$$= +2.0437\times10^{-18}\,J\,atom^{-1}$$

$$\therefore v = \frac{\Delta E}{h}$$

$$= \frac{2.0437\times10^{-18}\,J\,atom^{-1}}{6.625\times10^{-34}\,Js}$$

$$= 3.084\times10^{15}s^{-1}\ atom^{-1}$$

18. Given the mass of electron is $9.11\times10^{-31}\,kg$, Planck's constant is $6.626\times10^{-34}\,Js$, the uncertainty involved in the measurement of velocity within a distance of $0.1\,\mathring{A}$ is **[CBSE AIPMT 2006]**

(1) $5.79\times10^{6}\,ms^{-1}$ (2) $5.79\times10^{7}\,ms^{-1}$ (3) $5.79\times10^{8}\,ms^{-1}$ (4) $5.79\times10^{5}\,ms^{-1}$

(1)

By Heisenberg's uncertainty principle

$\Delta x \times \Delta p_x \geq \frac{h}{4\pi}$ or $\Delta x \times \Delta(mv_x) \geq \frac{h}{4\pi}$

$\Delta x \times \Delta v_x \geq \frac{h}{4\pi m}$

Δp = uncertainty in momentum

Δx = uncertainty in position

Δv = uncertainty in velocity

m = mass of particle

Given that,

$\Delta x = 0.1\,\text{Å} = 0.1 \times 10^{-10}$ m

$m = 9.11 \times 10^{-31}$ kg

h = Planck's constant $= 6.626 \times 10^{-34}$ Js

$\pi = 3.14$

Thus,

$$\Delta v \times 0.1 \times 10^{-10} = \frac{6.626 \times 10^{-34}}{4 \times 3.14 \times 9.11 \times 10^{-31}}$$

$$\Delta v = \frac{6.626 \times 10^{-34}}{4 \times 3.14 \times 9.11 \times 10^{-31} \times 0.1 \times 10^{-10}} \text{ ms}^{-1}$$

$= 5.785 \times 10^{6}$ ms^{-1}

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

19. The value of Planck's constant is 6.63×10^{-34} Js. The velocity of light is 3.0×10^{8} ms^{-1}. Which value is closest to the wavelength (in nanometer) of a quantum of light with frequency 8×10^{15} s^{-1}? **(CBSE AIPMT 2003)**

(1) 4×10^{1} (2) 3×10^{7} (3) 2×10^{-25} (4) 5×10^{-18}

(1)

$$\text{Frequency}(\nu) = \frac{c}{\lambda} = \frac{3 \times 10^{8}\text{ m s}^{-1}}{8 \times 10^{15}\text{ s}^{-1}}$$

$= 0.375 \times 10^{-7}$ m

$= 3.75 \times 10^{1}$ nm $\approx 4 \times 10^{1}$ nm

20. In hydrogen atom, energy of first excited state is –3.4 eV. Then, KE of same orbit of hydrogen atom is **[CBSE AIPMT 2002]**

(1) +3.4 eV (2) +6.8 eV (3) –13.6 eV (4) +13.6 eV

(1)

$\because$ Total energy (E_n) = KE + PE

In first excited state $= \frac{1}{2}mv^2 + \left[-\frac{Ze^2}{r}\right]$

$$= +\frac{1}{2}\frac{Ze^2}{r} - \frac{Ze^2}{r}$$

Energy of first excited state is 3.4eV

$$-3.4\text{eV} = -\frac{1}{2}\frac{Ze^2}{r}$$

$$\therefore \text{KE} = \frac{1}{2}\frac{Ze^2}{r} = +3.4\text{eV}$$

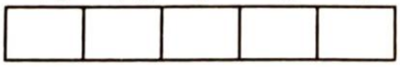
21. The following quantum numbers are possible for how many orbital(s) n = 3, l = 2 and m = +2? **[CBSE AIPMT 2001]**

(1) 1 (2) 2 (3) 3 (4) 4

$n = 3, l = 2, m = +2, s = \pm 1/2$

These values of quantum numbers are possible for only one of the five 3*d*-orbitals as +2 value of *m* is possible only for one orbital.

$m =$ +2 +1 0 −1 −2



22. Maximum number of electrons in a subshell with $l = 3$ and n = 4 is **[CBSE AIPMT 2012]**

(1) 14 (2) 16 (3) 10 (4) 12

(1)

n represents the main energy level and I represents the subshell. If n=4andl =3, the subshell is 4f. In f-subshell, there are 7 orbitals and each orbital can accommodate a maximum number of two electrons, so maximum number of electrons in 4f subshell = 7 × 2= 14.

24. The energy of photon is given as : **[CBSE AIPMT 2000]**

$\Delta e / \text{atom} = 3.03 \times 10^{-19}\text{J atom}^{-1}$, then the wavelength (λ) of the photon is

(Given, h (Planck's constant)

$= 6.63 \times 10^{-34}$ Js, c (velocity of light)

$= 3.00 \times 10^{8} \text{ms}^{-1}$)

(1) 6.56 nm (2) 65.6 nm (3) 656 nm (4) 0.656 nm

(3)

According to formula, $E = \frac{hc}{\lambda}\left(\nu = \frac{c}{\lambda}\right)$

Energy $E = h\nu$

$3.03 \times 10^{-19} = \frac{hc}{\lambda}$

$\lambda = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^{8}}{3.03 \times 10^{-19}}$

$= 6.56 \times 10^{-7}$ m

$= 6.56 \times 10^{-7} \times 10^{9}$ nm

$= 6.56 \times 10^{2}$ nm

$= 656$ nm

25. Two electrons occupying the same orbital are distinguished by: **(NEET 2016)**

(1) Magnetic quantum number (2) Azimuthal quantum number

(3) Spin quantum number (4) Principal quantum number

(3)

Two electrons occupying the same orbital has equal spin but the directions of their spin are opposite. Hence, spin quantum number, s, (represented +1/2 and – 1/2) distinguishes them.

26. How many electrons can fit in the orbital for which n = 3 and I = 1 ? **[NEET (Phase II) 2016]**

(1) 2 (2) 6 (3) 10 (4) 14

(1)

According to Hund's rule of maximum multiplicity, an orbital can accommodate a maximum number of 2 electrons of exactly opposite spin.
Caution remember, maximum number of electrons in an orbital do not depend upon the quantum numbers as given in the question

27. Which one is the wrong statement? **(NEET 2017)**

(1) de-Broglie's wavelength is given by $\lambda = \frac{h}{mv}$, where m = mass of the particle, v = group velocity of the particle

(2) The uncertainty principle is $\Delta E \times \Delta t \geq \frac{h}{4\pi}$

(3) Half-filled and fully filled orbitals have greater stability due to greater exchange energy, greater symmetry and more balanced arrangement.

(4) The energy of 2s-orbital less than the energy of 2p-orbital in case of Hydrogen like atoms.

(4)

(a) According to de-Broglie's equation,
Wavelength $(\lambda) = \frac{h}{mv}$
where, h = Planck's constant.
Thus, statement (a) is correct.

(b) According to Heisenberg uncertainty principle, the uncertainties of position (Δx) and momentum ($p = m\Delta v$) are related as

$$\Delta x . \Delta p \geq \frac{h}{4\pi}$$

or, $$\Delta x . m\Delta v \geq \frac{h}{4\pi}$$

$$\Delta x . m . \Delta a . \Delta t \geq \frac{h}{4\pi}$$

$$\left[\frac{\Delta v}{\Delta t} = \Delta a, a = \text{acceleration}\right]$$

or, $$\Delta x \cdot F \cdot \Delta t \geq \frac{h}{4\pi} \quad [\because F = m \cdot \Delta a]$$

or, $$\Delta E \cdot \Delta t \geq \frac{h}{4\pi}$$

$$[\because \Delta E = F \cdot \Delta x, E = \text{energy}]$$

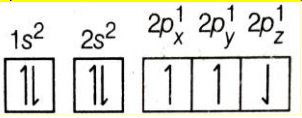
Thus, statement (b) is correct.

(c) The half and fully filled orbitals have greater stability due to greater exchange energy, greater symmetry and more balanced arrangement.
Thus statement (c) is correct.

(d) For a single electronic species like H, energy depends on value of n and does not depend on l. Hence energy of $2s$-orbital. and $2p$-orbital is equal in case of hydrogen like species.
Therefore, statement (d) is incorrect.

28. Which one is a wrong statement? **[NEET 2018]**

(1) The electronic configuration of N-atom is



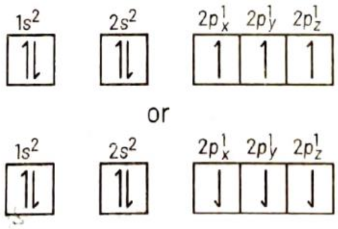
(2) An orbital is designated by three quantum numbers while an electron in an atom is designated by four quantum numbers

(3) Total orbital angular momentum of electron in's' orbital is equal to zero

(4) The value of m for d_{z^2} is zero

(1)

According to Hund's rule 'the pairing of electrons in the orbitals of a particular subshell does not takes place until all the orbitals of a subshell are singly occupied. Moreover, the singly orbitals must have the electrons with parallel spin. i.e.



∴ Option (a) is the incorrect option.

29. Orbital having 3 angular nodes and 3 total nodes is **[NEET (Odisha) 2019]**

(1) 5p (2) 3d (3) 4f (4) 6d

(3)

Angular node $(l) = 3$

Total node = radial node + angular node

$$3 = (n - l - 1) + l$$

$$3 = n - 1$$

$$\Rightarrow \quad n = 4$$

∴ Orbital having 3 angular nodes and 3 total nodes is $= nl = 4f$ [$\because l = 3$ for f-orbital]

30. 4d, 5p, 5f and 6p-orbitals are arranged in the order of decreasing energy. The correct option is **[NEET (National) 2019]**

(1) 6p>5f>5p>4d (2) 5p>5f>4d>5p

(3) 5f>6p>4d>5p (4) 5f>6p>5p>4d

(4)

The order of energy of orbitals can be calculated from $(n + l)$ rule. The lower the value of $(n + l)$ for an orbital, lower is its energy. If two orbitals have same $(n + l)$ value, the orbital with lower value of n has the lower energy.

(i) $6p = 6 + 1 = 7$ (ii) $5f = 5 + 3 = 8$

(iii) $4d = 4 + 2 = 6$ (iv) $5p = 5 + 1 = 6$

∴ The order of decreasing energy will be

$5f > 6p > 5p > 4d$.

31. 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] **[NEET (Odisha) 2019]**

(1) 211.6 pm (2) 211.6π pm (3) 52.9π pm (4) 105.8 pm

(2)

According to Bohr,

$$mvr = \frac{nh}{2\pi}$$

$$2\pi r = \frac{nh}{mv} = n\lambda \quad ...(i)\left[\because \lambda = \frac{h}{mv}\right]$$

Where, r = radius,

λ = wavelength

n = number of orbit

Also, $r = \frac{a_0 n^2}{Z}$ ...(ii)

Where, a0 = Bohr radius = 52.9 pm

Z = atomic number

On substituting the value of 'r' from Eq. (ii) to Eq. (i), we get

$$n\lambda = \frac{2\pi n^2 a_0}{Z}$$

$$\lambda = \frac{2\pi n a_0}{Z}$$

$$\lambda = 2\pi \times 2 \times 52.9 \qquad [\because n = 2, Z = 1]$$

$$= 211.6\pi pm$$

32. The number of angular nodes and radial nodes in 3s orbital are **[NEET (Oct.) 2020]**

(1) 0 and 2, respectively (2) 1 and 0, respectively

(3) 3 and 0, respectively (4) 0 and 1, respectively

(1)

For 3s-orbital, n = 3, l = 0

Number of radial nodes

= (n – *l* – 1) = 3 – 0 – 1 = 2

Number of angular nodes = *l* = 0.

Hence, option(1) is correct.

33. 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, $c = 3.0 \times 10^3$ ms^{-1}] **[NEET 2021]**

(1) 219.3m (2) 219.2 m (3) 2192 m (4) 21.92 cm

(1)

Frequency of electromagnetic radiation

$$v = 1368\,kHz$$

$$= 1368 \times 10^3 s^{-1}$$

Speed of light, $c = 3 \times 10^8 ms^{-1}$

Wavelength of electromagnetic Radiation,

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

$$\lambda = \frac{3 \times 10^8 ms^{-1}}{1368 \times 10^3 s^{-1}} = 219.3m$$

34. 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? **[NEET 2022]**

(1) 15.87 pm (2) 1.587 pm (3) 158.7 Å (4) 158.7pm

(4)

$r \propto \frac{n^2}{Z}$

$\frac{r_2}{r_1} = \frac{n_2^2}{n_1^2} \times \frac{Z_1}{Z_2}$

$\frac{r_2}{105.8} = \frac{(3)^2}{(2)^2} \times \frac{2}{3} = \frac{3}{2}$

$r_2 = 158.7$ pm