Chapter 02

Atomic Structure

JEE RANKER'S STUFF

SINGLE CORRECT QUESTIONS

Q.1 The orbital angular momentum for an electron revolving in an orbit is given by $\sqrt{\ell(\ell+1)}\cdot\frac{h}{2\pi}$ This momentum for an s-electron will be given by

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

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

Q.2 The de Broglie wavelength of a tennis ball of mass 60 g moving with a velocity of 10 meters per second is approximately:

(1) 10^{-25} meters (2) 10^{-33} meters

(3) 10^{-31} meters (4) 10^{-16} meters

Q.3 In Balmer series of lines of hydrogen spectrum, the third line from the red end corresponds to which one of the following inter-orbit jumps of the electron for Bohr orbits in an atom of hydrogen?

(1) $2 \rightarrow 5$ (2) $3 \rightarrow 2$

(3) $5 \rightarrow 2$ (4) $4 \rightarrow 1$

Q.4 According to Bohr's theory angular momentum of electron in 5th shell is :

(1) 1.0 h/π (2) 10 h/π

(3) 2.5 h/π (4) 25 h/π

Q.5 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 × 10^{-34} kg m^2 s^{-1}, mass of electron, e_m = 9.1 × 10^{-31} kg):

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

(3) 1.52 × 10^{-4} m (4) 5.10 × 10^{-3} m

Q.6 The frequency of light emitted for the transition n = 4 to n = 2 of He+ is equal to the transition in H atom corresponding to which of the following

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

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

Q.7 The de Broglie wavelength of a car of mass 1000 kg and velocity 36 km/hr is: (h = 6.63 × 10^{-34} Js)

(1) 6.626 × 10^{-31} m (2) 6.626 × 10^{-34} m

(3) 6.626 × 10^{-38} m (4) 6.626 × 10^{-30} m

Q.8 For which of the following particles will it be most difficult to experimentally verify the de-Broglie relationship?

(1) a dust particle (2) an electron

(3) a proton (4) a-particle

Q.9 Based on the equation

$\Delta E = -2.0 \times 10^{-18}\ J\left(\frac{1}{n_2^2}-\frac{1}{n_1^2}\right)$

the wavelength of the light that must be absorbed to excite hydrogen electron from level n = 1 to level n = 2 will be (h = 6.625 × 10^{-34} Js, C = 3 × 10^8 ms^{-1})

(1) 2.650 × 10^{-7} m (2) 1.325 × 10^{-7} m

(3) 1.325 × 10^{-10} m (4) 5.300 × 10^{-10} m

Q.10 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) $\sqrt{\frac{2hc}{m}\left(\frac{\lambda_0-\lambda}{\lambda\lambda_0}\right)}$ (2) $\sqrt{\frac{2h}{m}\left(\frac{1}{\lambda_0}-\frac{1}{\lambda}\right)}$

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

Q.11 Ionization energy of gaseous Na atoms is 495.5 $kjmol^{-1}$. The lowest possible frequency of light that ionizes a sodium atom is (h = 6.626 × 10^{-34} Js, N_A = 6.022 × 10^{23} mol^{-1})

(1) 3.15 × 10^{15} s^{-1} (2) 4.76 × 10^{14} s^{-1}

(3) 1.24 × 10^{15} s^{-1} (4) 7.50 × 10^4 s^{-1}

Q.12 At temperature T, the average kinetic energy of any particle is kT The de Broglie wavelength follows the order :

(1) Visible photon > Thermal electron > Thermal neutron

(2) Thermal proton > Thermal electron > Visible photon

(3) Visible photon > Thermal neutron > Thermal electron

(4) Thermal proton > Visible photon > Thermal electron

Q.13 For emission line of atomic hydrogen from n_i = 8 to n_f = the plot of wave number $\left(\bar{\nu}\right)$ against $\left(\frac{1}{n^2}\right)$ will be (The Rydberg constant, RH is in wave number unit).

(1) Linear- with slope – RH

(2) Linear with intercept – RH

(3) Non linear

(4) Linear with slope RH

Q.14 Which of the following combination of statements is true regarding the interpretation of the atomic orbitals ?

(a) An electron in an orbital of high angular momentum stays away from the nucleus than an electron in the orbital of lower angular momentum.

(b) For a given value of the principal quantum number, the size of the orbit is inversely proportional to the azimuthal quantum number.

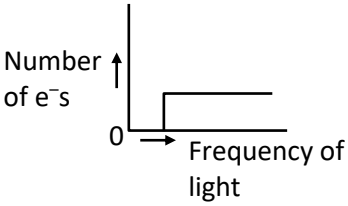
(c) According to wave mechanics, the ground state angular momentum is equal to $\frac{h}{2\pi}$

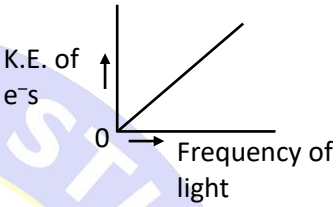
(d) The plot of ψ Vs r for various azimuthal quantum numbers, shows peak shifting towards higher r value.

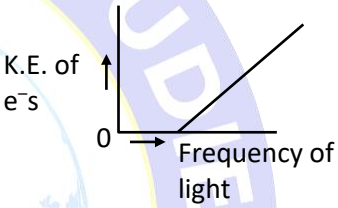
(1) (a), (c) (2) (a), (d)

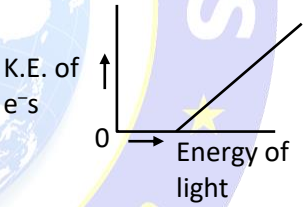
(3) (b), (c) (4) (a), (b)

Q.15 Which of the graphs shown below does not represent the relationship between incident light and the electron ejected from metal surface?

(1) 

(2) 

(3) 

(4) 

Q.16 Ionisation energy of He^+ is 19.6×10^{-18} J atom^{-1}. The energy of the first stationary state (n = 1) of Li^{2+} is:

(1) 8.82×10^{-17} J atom^{-1}

(2) 4.41×10^{-16} J atom^{-1}

(3) -4.41×10^{-17} J atom^{-1}

(4) -2.2×10^{-15} J atom^{-1}

Q.17 The electrons identified by quantum numbers n and l :

(a) n = 4 , λ = 1 (b) n = 4, λ = 0

(c) n = 3, λ = 2 (d) n = 3, λ = 1

Can be placed in order of increasing energy as

(1) (a) < (c) < (b) < (d)

(2) (c) < (d) < (b) < (a)

(3) (d) < (b) < (c) < (a)

(4) (b) < (d) < (a) < (c)

Q.18 If the kinetic energy of an electron is increased four times, the wavelength of the de-Broglie wave associated with it would become :

(1) Two times (2) Half

(3) One fourth (4) Four times

Q.19 If the radius of first orbit of H atom is a_0, the de-Broglie wavelength of an electron in the third orbit is :

(1) $6\pi a_0$ (2) $8\pi a_0$

(3) $2\pi a_0$ (4) $4\pi a_0$

Q.20 The wave number of the first emission line in the Balmer series of H-Spectrum is :
(R = Rydberg constant) :

(1) $\frac{3}{4}R$ (2) $\frac{9}{400}R$

(3) $\frac{5}{36}R$ (4) $\frac{7}{6}R$

Q.21 The correct Schrodinger's wave equation for an electron with E as total energy and V as potential energy is :

(1) $\frac{\partial^2\psi}{\partial x^2}+\frac{\partial^2\psi}{\partial y^2}+\frac{\partial^2\psi}{\partial z^2}+\frac{8\pi^2}{mh^2}(E-V)\psi=0$

(2) $\frac{\partial^2\psi}{\partial x^2}+\frac{\partial^2\psi}{\partial y^2}+\frac{\partial^2\psi}{\partial z^2}+\frac{8\pi m}{h^2}(E-V)\psi=0$

(3) $\frac{\partial^2\psi}{\partial x^2}+\frac{\partial^2\psi}{\partial y^2}+\frac{\partial^2\psi}{\partial z^2}+\frac{8\pi^2 m}{h^2}(E-V)\psi=0$

(4) $\frac{\partial^2\psi}{\partial x^2}+\frac{\partial^2\psi}{\partial y^2}+\frac{\partial^2\psi}{\partial z^2}+\frac{8\pi m^2}{h}(E-V)\psi=0$

NUMERICAL VALUE TYPE QUESTIONS

Q.22 The work function (ϕ) of some metals is listed below. The number of metals which will show photelectric effect when light of 300 nm wavelength falls on the metal is

Metal	Li	N	K	Mg	Cu	Ag	Fe	Pt	W
ϕ(eV)	2.4	2.3	2.2	2.7	4.8	4.3	4.7	6.3	4.75

Q.23 The energy of separation of an electron is 30.6 eV moving in an orbit of Li^{+2}. Find out the number of waves made by the electron in one complete revolution in the orbit.

Q.24 The uncertainty in position and velocity of a particle are 10^{-11} m and 5.27×10^{-24} $m\cdot s^{-1}$, respectively. The minimum mass of the particle (in kg) is.

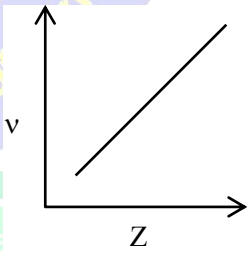
Q.25 The energy required to break one mole of Cl–Cl bonds in Cl_2 is 242 kJ mol^{-1}. The longest wavelength of light capable of breaking a single Cl–Cl bond is ($C = 3 \times 10^8$ ms^{-1} and $NA = 6.02 \times 10^{23}$ mol^{-1})

Q.26 If the binding energy of the electron in a hydrogen atom is 13.6 eV, the energy required to remove the electron from the first excited state of Li^{++} is:

Q.27 The radius of the second Bohr orbit for hydrogen atom is :
(Plank's const. $h = 6.6262 \times 10^{-34}$ Js
mass of electron = 9.1091×10^{-31} kg
charge of electron $e = 1.60210 \times 10^{-19}$ C
permittivity of vacuum $\in_0 = 8.854185 \times 10^{-12}$ kg^{-1} m^{-3} A^2)

Q.28 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 :

Q.29 It is observed that characteristic X-ray spectra of elements show regularity. When frequency to the power 'n' i.e. ν^n of X-rays emitted is plotted against atomic number 'Z', following graph is obtained.



The value of 'n' is

Q.30 How many of the following metal ions have similar value of spin only magnetic moment in gaseous state ? _____
(Given: Atomic : V, 23; Cr, 24 ; Fe, 26 ; Ni, 28)
V^{3+}. Cr^{3+}, Fe^{2+}, Ni^{3+}

Q.31 The energy of one mole of photons of radiation of frequency 2×10^{12}Hz in J mol^{-1} is ____. (Nearest integer)
(Given: $h = 6.626 \times 10^{-34}$ Js $N_A = 6.022 \times 10^{23}$ mol^{-1})

STATEMENT TYPE QUESTIONS

Each question contains STATEMENT-1 (Assertion) and STATEMENT-2 (Reason.)
Examine the statements carefully and mark the correct answer according to the instructions given below

(1) If both the statements are correct and STATEMENT-2 is the correct explanation of STATEMENT-1.
(2) If both the statements are correct but STATEMENT-2 is NOT the correct explanation of STATEMENT-1.
(3) If STATEMENT-1 is correct and STATEMENT-2 is incorrect.
(4) If STATEMENT-1 is incorrect and STATEMENT-2 is correct.

Q.32 **Statement-1:** The angular momentum of d-orbitals is $\sqrt{6}\frac{h}{2\pi}$
Statement-2: Angular momentum of electron in orbit is mvr = $\frac{nh}{2\pi}$
(1) A (2) B (3) C (4) D

Q.33 **Statement-1:** Emitted radiation will fall invisible range when an electron jump from n = 4 to n = 2 in H-atom.
Statement-2 : Balmer series radiation belong to visible range for hydrogen atom only.
(1) A (2) B (3) C (4) D

Q.34 **Statement-1:** The ground state electronic configuration of nitrogen is

STATEMENT-2: Electron are filled in orbital as per Aufbau principle, Hund's rule of maximum spin multiplicity and pauli's principle
(1) A (2) B (3) C (4) D

Q.35 **Statement-1:** Cu^{+2} is a coloured ion.
Statement-2: Any ion with unpaired electron is coloured.
(1) A (2) B (3) C (4) D

Q.36 **Statement-1:** Helium and beryllium have similar outer electronic configuration ns^2
Statement-2: Both are chemically inert.
(1) A (2) B (3) C (4) D

Q.37 **Statement-1:** Spin quantum number can have two values $+\frac{1}{2}$ and $-\frac{1}{2}$.
Statement-2: +ve and –ve signs signify the positive and negative wave functions.
(1) A (2) B (3) C (4) D

Q.38 **Statement 1:** Kinetic energy of photoelectrons is directly proportional to the intensity of the incident radiation
Statement 2: Each photon of light causes the emission of only one photoelectrons
(1) A (2) B (3) C (4) D

Q.39 **Statement 1:** An orbital cannot have more than two electrons
Statement 2: The two electrons in an orbital create opposite magnetic field.
(1) A (2) B (3) C (4) D

Q.40 **Statement 1:** The radius of second orbit of He^+ is equal to that of first orbit of hydrogen
Statement 2: The radius of an orbit in hydrogen like species is directly proportional to n^2 and inversely proportional to Z
(1) A (2) B (3) C (4) D

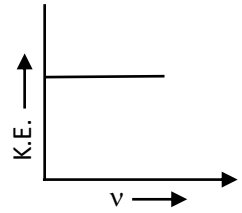
MORE THAN ONE CORRECT TYPE QUESTIONS

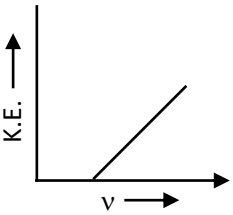
Q.41 The angular momentum of electron can have the value (S) :
(1) $0.5\frac{h}{\pi}$ (2) $\frac{h}{\pi}$
(3) $\frac{h}{0.5\,\pi}$ (4) $2.5\frac{h}{2\,\pi}$

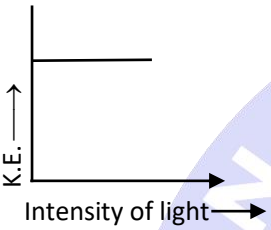
Q.42 For radial probability curves, which of the following is/are correct?
(1) The number of maxima in 2s orbital are two
(2) The number of spherical or radial nodes is equal to $n - \ell - 1$
(3) The number of angular nodes are 'ι'
(4) $3d_2^2$ has 3 angular nodes

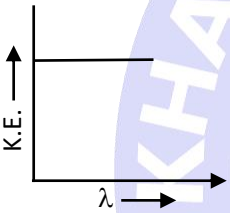
Q.43 Hydrogen has :
(1) half filled subshell
(2) half filled shell
(3) one electron in valence shell
(4) half filled orbital

Q.44 Which is/are correct graph ?

(1) 

(2) 

(3) 

(4) 

Q.45 In a sample of H-atom electrons are de-excited from 4^{th} excited state to ground state. Which is/are correct statement?

(1) No line observed in p-fund series.
(2) Total ten lines observed in spectrum
(3) 4 line in UV-region and 3 line in visible region observed
(4) One line observed in Brackett series.

Q.46 Select the correct statement (s) :

(1) Lower value of quantum number ℓ indicates that there is a higher probability of finding the electron close to the nucleus than those of 3p and 3d electrons
(2) Energy of 3s orbital is less than for the 3p and 3d orbitals
(3) At the node, the value of the radial function changes from positive to negative
(4) The radial function depends upon the quantum numbers n and ℓ

COMPREHENSION TYPE QUESTIONS

Q.47 Werner Heisenberg considered the limits of how precisely we can measure the properties of an electron or other microscopic particle. He determined that there is a fundamental limit to how closely we can measure both position and momentum. The more accurately we measure the momentum of a particle, the less accurately we can determine its position. The converse is also true. This is summed up in what we now call the Heisenberg uncertainty principle.

The equation is $\Delta x.\Delta(mv) \geq \frac{h}{4\pi}$

The uncertainty in the position or in the momentum of a macroscopic object like a baseball is too small to observe. However, the mass of microscopic object such as an electron is small enough for the uncertainty to be relatively large and significant.

(i) If the uncertainties in position and momentum are equal, the uncertainty in the velocity is:

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

(3) $\frac{1}{2m}\sqrt{\frac{h}{\pi}}$ (4) None of these

(ii) If the uncertainty in velocity and position is same, then the uncertainty in momentum will be:

(1) $\sqrt{\frac{hm}{4\pi}}$ (2) $m\sqrt{\frac{h}{4\pi}}$

(3) $\sqrt{\frac{h}{4\pi m}}$ (4) $\frac{1}{m}\sqrt{\frac{h}{4x}}$

(iii) What would be the minimum uncertainty in de-Broglie wavelength of a moving electron accelerated by potential difference of 6 volt and whose uncertainty in position is $\frac{7}{22}$nm ?

(1) 6.25 Å (2) 6 Å
(3) 0.625 Å (4) 0.3125 Å

Q.48 If hydrogen atoms (in the ground state) are passed through an homogeneous magnetic field, the beam is split into parts. This interaction with the magnetic field shows that atoms must have magnetic moment. However, the moment cannot be due to the orbital angular momentum since l = 0. Hence one must

assume existence of intrinsic angular momentum, which as the experiment shows, has only two permitted orientations.

Spin of the electron produce angular momentum equal to $S=\sqrt{s(s+1)}\frac{h}{2\pi}$

where S = $+\frac{1}{2}$.

Total spin of an atom = $+\frac{n}{2}$ or $-\frac{n}{2}$

Where n is the number of unpaired electrons.

The substance which contain species with unpaired electrons in their orbitals behave as paramagnetic substances. The paramagnetism is expressed in terms of magnetic moment.

The magnetic moment of an atom.

$$\mu_s\sqrt{s(s+1)}\frac{eh}{2\pi mc}=\sqrt{\frac{n}{2}\left(\frac{n}{2}+1\right)}\frac{eh}{2\pi mc},s=\frac{n}{2}$$

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

n = number of unpaired electrons

1. B.M. (Bohr magneton) = $\frac{eh}{4\pi mc}$

If magnetic moment is zero the substance is diamagnetic.

(i) Which of the following ion has lowest magnetic moment?

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

(ii) If an ion of $_{25}Mn$ has a magnetic moment of 3.873 B.M. Then oxidation state of Mn in ion is:

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

MATCH THE COLUMN TYPE QUESTIONS

Column-I and Column-II contain four entries in each. Entries of Column-I are to be matched with some entries of Column-II. One or more than one entries of Column-I may have the matching with the same entries of Column-II.

Q.49

Column-I	Column-II
(A) Electron	(P) Negative charge
(B) Proton	(Q) Positive charge
(C) Neutron	(R) 1.6×10^{-19} C
(D) Positron	(S) Chargeless

(1) A→P, R; B→Q, R; C→S; D→R, Q

(2) A→R, P; B→R, Q; C→S; D→Q, R

(3) A→R, P; B→Q, R; C→S; D→R, Q

(4) A→P, R; B→Q, R; C→S; D→Q, R

Q.50

Column-I	Column-II
(A) $\frac{K.E.}{P.E.}$	(P) 2
(B) P.E. + 2 K.E.	(Q) $-\frac{1}{2}$
(C) $\frac{P.E.}{T.E.}$	(R) –1
(D) $\frac{K.E.}{T.E.}$	(S) 0

(1) A→R; B→P; C→Q; D→S

(2) A→Q; B→S; C→R; D→P

(3) A→Q; B→S; C→P; D→R

(4) A→S; B→P; C→R; D→Q

Q.51 In case of hydrogen spectrum wave number is given by

$\bar{\nu}=R_H\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right]$ Where $n_1 < n_2$

Column-I	Column-II
(A) Lyman series	(P) n_2 =2
(B) Balmer series	(Q) n_2 =3
(C) pfund series	(R) n_2 =6
(D) Brackett series	(S) n_2 =5

(1) A→P, Q, R, S; B→Q, R, S; C→R; D→R, S

(2) A→R, P, Q, S; B→S, Q, R; C→R; D→R, S

(3) A→P, Q, R, S; B→P, S, R; C→S; D→S, R

(4) A→S, R, Q, P; B→Q, R, S; C→R; D→R, S

Q.52

Column-I	Column-II
(A) Orbital angular momentum of an electron	(P) $\sqrt{s(s+1)}\frac{h}{2\pi}$
(B) Angular momentum of an electron in an orbit	(Q) $\sqrt{n(n+2)}$
(C) Spin angular momentum of an electron	(R) $\frac{nh}{2\pi}$

(D) Magnetic moment of atom	(S) $\sqrt{\ell(\ell+1)}\,\frac{h}{2\pi}$

(1) A→ Q; B→P; C→S; D→R
(2) A→ S; B→R; C→P; D→Q
(3) A→ R; B→S; C→P; D→Q
(4) A→ P; B→Q; C→S; D→R

Q.53

Column-I	Column-II
(A) 2s	(P) n = 4, l = 2, m = 0
(B) $2p_z$	(Q) n = 4, l = 2, m = –2 or +2
(C) $4d_{x^2-y^2}$	(R) n = 2, l = 1, m = 0
(D) $4d_{z^2}$	(S) n = 2, l = 0, m = 0

(1) A→ S; B→R; C→P; D→Q
(2) A→ R; B→S; C→Q; D→P
(3) A→ S; B→R; C→Q; D→P
(4) A→ Q; B→P; C→S; D→R

ANSWER KEY

JEE RANKER'S STUFF

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	3	2	3	3	1	2	3	1	2	1	3	1	4	1	2
Que.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans.	3	3	2	1	3	3	4	2	1	494	30.6	2.12	743	0.5	2
Que.	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Ans.	798	2	1	1	3	3	3	4	2	4	1,2,3	1,2,3	1,2,3,4	2,3	1,2,3,4
Que.	46	47(i)	47(ii)	47(iii)	48(i)	48(ii)	49	50	51	52	53				
Ans.	1,2,3,4	3	1	3	4	3	4	3	1	2	3				