EXERCISE-01 CHECK YOUR GRASP

SELECT THE CORRECT ALTERNATIVE (ONLY ONE CORRECT ANSWER)

1. The element having no neutron in the nucleus of its atom is -
(A) hydrogen (B) nitrogen (C) helium (D) boron

2. The particles present in the nucleus of an atom are -
(A) the proton and the electron (B) the electron and the neutron
(C) the proton and the neutron (D) none of these

3. The fraction of volume occupied by the nucleus with respect to the total volume of an atom is -
(A) 10^{-15} (B) 10^{-5} (C) 10^{-30} (D) 10^{-10}

4. Which of the following is iso-electronic with neon -
(A) O^{2-} (B) F^{+} (C) Mg (D) Na

5. The approximate size of the nucleus of $^{64}_{28}Ni$ is -
(A) 3 fm (B) 4 fm (C) 5 fm (D) 2 fm

6. Which is true about an electron -
(A) rest mass of electron is $9.1 \quad 10^{-28}$ g
(B) mass of electron increases with the increase in velocity
(C) molar mass of electron is $5.48 \quad 10^{-4}$ g/mole
(D) e/m of electron is $1.7 \quad 10^{8}$ coulomb/g

7. An isotone of $^{76}_{32}Ge$ is -
(A) $^{77}_{32}Ge$ (B) $^{77}_{33}As$ (C) $^{77}_{34}Se$ (D) $^{78}_{34}Se$

8. When alpha particles are sent through a thin metal foil, most of them go straight through the foil because -
(A) alpha particles are much heavier than electrons
(B) alpha particles are positively charged
(C) most part of the atom is empty space
(D) alpha particles move with high speed

9. Many elements have nonintegral atomic masses because -
(A) they have isotopes
(B) their isotopes have non-integral masses
(C) their isotopes have different masses
(D) the constituents, neutrons, protons and electrons combine to give fractional masses

10. The MRI (magnetic resonance imaging) body scanners used in hospitals operate with 400 MHz radio frequency energy. The wavelength corresponding to this radio frequency is -
(A) 0.75 m (B) 0.75 cm (C) 1.5 m (D) 2 cm

11. Photon of which light has maximum energy -
(A) Red (B) Blue (C) Violet (D) Green

12. The value of Planck's constant is $6.63 \quad 10^{-34}$ Js. The velocity of light is $3 \quad 10^{8}$ m/sec. Which value is closest to the wavelength in nanometer of a quantum of light with frequency of $8 \quad 10^{15}$ sec^{-1} -
(A) $5 \quad 10^{-18}$ (B) $4 \quad 10^{1}$ (C) $3 \quad 10^{7}$ (D) $2 \quad 10^{-25}$

13. Bohr's theory is not applicable to -
(A) He (B) Li^{2+} (C) He^{2+} (D) the H-atom

14. What is likely to be principal quantum number for a circular orbit of diameter 20 nm of the hydrogen atom if we assume Bohr orbit be the same as that represented by the principal quantum number ?

(A) 10 (B) 14 (C) 12 (D) 16

15. Which is the correct relationship -

(A) E_1 of H = 1/2 E_2 of He^+ = 1/3 E_3 of Li^{2+} = 1/4 E_4 of Be^{3+}

(B) $E_1(H) = E_2(He^+) = E_3(Li^{2+}) = E_4(Be^{3+})$

(C) $E_1(H) = 2E_2(He^+) = 3E_3(Li^{2+}) = 4E_4(Be^{3+})$

(D) No relation

16. If the value of E = – 78.4 kcal/mole, the order of the orbit in hydrogen atom is -

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

17. If velocity of an electron in 1^{st} orbit of H atom is V, what will be the velocity of 3^{rd} orbit of Li^{+2} -

(A) V (B) V/3 (C) 3 V (D) 9 V

18. In a certain electronic transition in the hydrogen atoms from an initial state (1) to a final state (2), the difference in the orbit radius ($r_1 - r_2$) is 24 times the first Bohr radius. Identify the transition -

(A) 5 → 1 (B) 25 → 1 (C) 8 → 3 (D) 7 → 5

19. Match the following -

(a)	Energy of ground state of He^+	(i)	–6.04 eV
(b)	Potential energy of I orbit of H-atom	(ii)	–27.2 eV
(c)	Kinetic energy of II excited state of He^+	(iii)	8.7 10^{-18} J
(d)	Ionisation potential of He^+	(iv)	–54.4 eV

(A) A – (i), B – (ii), C – (iii), D – (iv) (B) A – (iv), B – (iii), C – (ii), D – (i)

(C) A – (iv), B – (ii), C – (i), D – (iii) (D) A – (ii), B – (iii), C – (i), D – (iv)

20. The energy of hydrogen atom in its ground state is –13.6 eV. The energy of the level corresponding to n = 5 -

(A) –0.54 eV (B) –5.40 eV (C) –0.85 eV (D) –2.72 eV

21. Total no. of lines in Lyman series of H spectrum will be -

(where n = no. of orbits)

(A) n (B) n – 1 (C) n – 2 (D) n (n + 1)

22. The spectrum of He^+ is expected to be similar to that of -

(A) Li^+ (B) He (C) H (D) Na

23. What possibly can the ratio be of the de Broglie wavelengths for two electrons having the same initial energy and accelerated through 50 volts and 200 volts ?

(A) 3 : 10 (B) 10 : 3 (C) 1 : 2 (D) 2 : 1

24. The uncertainty in the momentum of an electron is 1.0 10^{-5} kg m s^{-1}. The uncertainty of its position will be (h = 6.626 10^{-34} kg m^2 s^{-1}) -

(A) 1.05 10^{-28} m (B) 1.05 10^{-26} m (C) 5.27 10^{-30} m (D) 5.25 10^{-28} m

25. An α-particle is accelerated through a potential difference of V volts from rest. The de-Broglie's wavelength associated with it is -

(A) $\sqrt{\frac{150}{V}} A^\circ$ (B) $\frac{0.286}{\sqrt{V}} A^\circ$ (C) $\frac{0.101}{\sqrt{V}} A^\circ$ (D) $\frac{0.983}{\sqrt{V}} A^\circ$

26. The orbital with zero angular momentum is -

(A) s (B) p (C) d (D) f

27. Which of the following is electronic configuration of Cu^{2+} (Z = 29) -

(A) $[Ar]4s^1\ 3d^8$ (B) $[Ar]4s^2\ 3d^{10}\ 4p^1$ (C) $[Ar]4s^1\ 3d^{10}$ (D) $[Ar]\ 3d^9$

28. The electronic configuration of the Mn^{4+} ion is -

(A) $3d^4 4s^0$ (B) $3d^2 4s^1$ (C) $3d^1 4s^2$ (D) $3d^3 4s^0$

29. Which of the following ions has the maximum number of unpaired d-electrons -

(A) Zn^{2+} (B) Fe^{2+} (C) Ni^{3+} (D) Cu^+

30. The total spin resulting from a d^7 configuration is -

(A) 1 (B) 2 (C) 5/2 (D) 3/2

31. Given

	K	L	M	N
	2	8	11	2

The number of electrons present in ℓ = 2 is -

(A) 3 (B) 6 (C) 5 (D) 4

32. The configuration $1s^2\ 2s^2\ 2p^5\ 3s^1$ shows the -

(A) ground state of the fluorine atom (B) excited state of the fluorine atom

(C) excited state of the neon atom (D) excited state of O_2^- ion

33. The value ℓ and m for the last electron in the Cl^- ion are -

(A) 1 and 2 (B) 2 and +1 (C) 3 and –1 (D) 1 and –1

34. In which transition, one quantum of energy is emitted -

(A) $n = 4 \rightarrow n = 2$ (B) $n = 3 \rightarrow n = 1$ (C) $n = 4 \rightarrow n = 1$ (D) $n = 2 \rightarrow n = 1$

35. Choose the correct relation on the basis of Bohr's theory -

(A) velocity of electron $\propto \frac{1}{n}$ (B) frequency of revolution $\propto \frac{Z^2}{n^3}$

(C) radius of orbit $\propto n^2 Z$ (D) force on electron $\propto \frac{Z^3}{n^4}$

36. The magnitude of the spin angular momentum of an electron is given by -

(A) $S = \sqrt{s(s+1)}\frac{h}{2\pi}$ (B) $S = s\frac{h}{2\pi}$ (C) $S = \frac{\sqrt{3}}{2} \times \frac{h}{2\pi}$ (D) $S = \pm \frac{1}{2} \times \frac{h}{2\pi}$

37. The change in orbital angular momentum corresponding to an electron transition inside a hydrogen atom can be -

(A) $\frac{h}{4\pi}$ (B) $\frac{h}{\pi}$ (C) $\frac{h}{2\pi}$ (D) $\frac{h}{8\pi}$

38. In which of these options do both constituents of the pair have the same magnetic moment -

(A) Zn^{2+} and Cu^+ (B) Co^{2+} and Ni^{2+} (C) Mn^{4+} and Co^{2+} (D) Mg^{2+} and Sc^+

CHECK YOUR GRASP — ANSWER KEY — EXERCISE -1

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	A	C	A	A	C	A,B,C,D	B,D	A,C	A,C	A	C	B	A,C	B	B
Que.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans.	C	A	A	C	A	B	C	D	C	C	A	D	D	B	D
Que.	31	32	33	34	35	36	37	38							
Ans.	A	C	D	A,B,C,D	A,B,D	A,C	B,C	A,C							

EXERCISE–02 BRAIN TEASERS

SELECT THE CORRECT ALTERNATIVES (ONE OR MORE THEN ONE CORRECT ANSWERS)

1. The maximum energy is present in any electron at :-

(A) Nucleus (B) Ground state

(C) First excited state (D) Infinite distance from the nucleus

2. Which electronic level would allow the hydrogen atom to absorb a photon but not to emit a photon :-

(A) 3s (B) 2p (C) 2s (D) 1s

3. The third line in Balmer series corresponds to an electronic transition between which Bohr's orbits in hydrogen :-

(A) $5 \to 3$ (B) $5 \to 2$ (C) $4 \to 3$ (D) $4 \to 2$

4. Correct set of four quantum numbers for valence electron of rubidium (Z = 37) is :-

(A) $5, 0, 0, +\frac{1}{2}$ (B) $5, 1, 0, +\frac{1}{2}$ (C) $5, 1, 1, +\frac{1}{2}$ (D) $6, 0, 0, +\frac{1}{2}$

5. The orbital diagram in which the Aufbau's principle is violated is :-

(A) $2s$ ↑↓ $2p_x$ ↑↓ $2p_y$ ↑ $2p_z$

(B) $2s$ ↑ $2p_x$ ↑↓ $2p_y$ ↑ $2p_z$ ↑

(C) $2s$ ↑↓ $2p_x$ ↑ $2p_y$ ↑ $2p_z$ ↑

(D) $2s$ ↑↓ $2p_x$ ↑↓ $2p_y$ ↑↓ $2p_z$ ↑

6. The total number of neutrons in dipositive zinc ions with mass number 70 is :-

(A) 34 (B) 40 (C) 36 (D) 38

7. Which of the following sets of quantum numbers represent an impossible arrangement :-

	n	l	m	m_s
(A)	3	2	–2	$\frac{1}{2}$
(B)	4	0	0	$\frac{1}{2}$
(C)	3	2	–3	$\frac{1}{2}$
(D)	5	3	0	$\frac{1}{2}$

8. The explanation for the presence of three unpaired electrons in the nitrogen atom can be given by :-

(A) Pauli's exclusions principle (B) Hund's rule

(C) Aufbau's principle (D) Uncertainty principle

9. The electronic configuration of an element is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^1$. This represents its :-

(A) Excited state (B) Ground state (C) Cationic form (D) None

10. Which of the following has maximum number of unpaired electron (atomic number of Fe 26) :-

(A) Fe (B) Fe (II) (C) Fe (III) (D) Fe (IV)

11. Which quantum number is not related with Schrodinger equation :-

(A) Principal (B) Azimuthal (C) Magnetic (D) Spin

12. If λ_0 is the threshold wavelength for photoelectric emission, λ wavelength of light falling on the surface of metal, and m mass of electron, then de Broglie wavelength of emitted electron is :-

(A) $\left[\frac{h(\lambda\lambda_0)}{2mc(\lambda_0 - \lambda)}\right]^{\frac{1}{2}}$ (B) $\left[\frac{h(\lambda_0 - \lambda)}{2mc\lambda\lambda_0}\right]^{\frac{1}{2}}$ (C) $\left[\frac{h(\lambda - \lambda_0)}{2mc\lambda\lambda_0}\right]^{\frac{1}{2}}$ (D) $\left[\frac{h\lambda\lambda_0}{2mc}\right]^{\frac{1}{2}}$

13. It is known that atom contain protons, neutrons and electrons. If the mass of neutron is assumed to half of its original value where as that of proton is assumed to be twice of its original value then the atomic mass of ${}^{14}_{6}C$ will be :-

(A) same
(B) 25 % more
(C) 14.28 % more
(D) 28.5 % less

14. Give the correct order of initials T (true) or F (false) for following statements :-

(I) If an ion has 2 electrons in K shell, 8 electrons in L shell and 6 electrons in M shell, then number of S electrons present in that element is 6.

(II) The maximum number of electrons in a subshell is given by $2n^2$

(III) If electron has magnetic quantam number −1, then it cannot be present in s-orbital.

(IV) Only one radial node is present in 3p orbital.

(A) TTFF
(B) FFTF
(C) TFTT
(D) FFTF

15. The shortest wavelength of He^+ in Balmer series is x, then longest wavelength in the Paschene series of Li^{+2} is :-

(A) $\frac{36x}{5}$
(B) $\frac{16x}{7}$
(C) $\frac{9x}{5}$
(D) $\frac{5x}{9}$

16. An electron in a hydrogen atom in its ground state absorbs energy equal to ionisation energy of Li^{+2}. The wavelength of the emitted electron is :-

(A) 3.32 10^{-10} m
(B) 1.17 Å
(C) 2.32 10^{-9} nm
(D) 3.33 pm

17. In compound $FeCl_2$ the orbital angular momentum of last electron in its cation & magnetic moment (in Bohr Magneton) of this compound are :-

(A) $(\sqrt{6})\hbar, \sqrt{35}$
(B) $(\sqrt{6})\hbar, \sqrt{24}$
(C) $0, \sqrt{35}$
(D) none of these

18. An electron, a proton and an alpha particle have kinetic energy of 16 E, 4E and E respectively. What is the qualitative order of their de Broglie wavelengths :-

(A) $\lambda_e > \lambda_p = \lambda_\alpha$
(B) $\lambda_p = \lambda_\alpha > \lambda_e$
(C) $\lambda_p > \lambda_e > \lambda_\alpha$
(D) $\lambda_\alpha < \lambda_e >> \lambda_p$

19. Question : Is the specie paramagnetic ?

STATE-1 : The atomic number of specie is 29.

STATE-2 : The charge on the specie is +1.

(A) Statements (1) alone is sufficient but statement (2) is not sufficient

(B) Statement (2) alone is sufficient but statement (1) is not sufficient

(C) Both statement together are sufficient but neither statement alone is sufficient

(D) Statement (1) & (2) together are not sufficient

20. Given ΔH for the process Li (g) $\longrightarrow$ Li^{+3} (g) + $3e^-$ is 19800 kJ/mole & IE_1 for Li is 520 then IE_2 & IE_1 of Li^+ are respectively (approx value) :-

(A) 11775, 7505
(B) 19280, 520
(C) 11775, 19280
(D) Data insufficient

21. The ratio of difference in wavelengths of 1st and 2nd lines of Lyman series in H-like atom to difference in wavelength for 2nd and 3rd lines of same series is :-

(A) 2.5 : 1
(B) 3.5 : 1
(C) 4.5 : 1
(D) 5.5 : 1

22. Which of the following statement is INCORRECT.

(A) $\frac{e}{m}$ ratio for canal rays is maximum for hydrogen ion.

(B) $\frac{e}{m}$ ratio for cathode rays is independent of the gas taken.

(C) The nature of canal rays is dependent on the electrode material.

(D) The $\frac{e}{m}$ ratio for electron is expressed as $\frac{E^2}{2B^2V}$,when the cathode rays go undeflected under the influence of electric field (E), magnetic field (B) and V is potential difference applied across electrodes.

23. The quantum numbers of four electrons (e1 to e4) are given below :-

	n	ℓ	m	s
e1	3	0	0	+1/2
e2	4	0	1	1/2
e3	3	2	2	–1/2
e4	3	1	–1	1/2

The correct order of decreasing energy of these electrons is :

(A) e4 > e3 > e2 > e1

(B) e2 > e3 > e4 > e1

(C) e3 > e2 > e4 > e1

(D) none

24. If radius of second stationary orbit (in Bohr's atom) is R. Then radius of third orbit will be :-

(A) R/3

(B) 9R

(C) R/9

(D) 2.25 R

25. The wavelength associated with a gold weighing 200 g and moving at a speed of 5 m/h is of the order :-

(A) 10^{-10} m

(B) 10^{-20} m

(C) 10^{-30} m

(D) 10^{-40} m

26. If the nitrogen atom had electronic configuration $1s^7$, it would have energy lower that of normal ground state configuration $1s^2\ 2s^2\ 2p^3$, because the electrons would be closer to the nucleus. Yet $1s^7$ is not observed because it violates :-

(A) Heisenberg uncertainty principle

(B) Hunds rule

(C) Pauli's exclusion principle

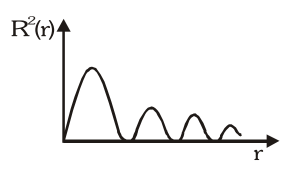
(D) Bohr postulate of stationary orbits

27. From the following observations predict the type of orbital :

Observation 1 : x y plane acts as nodal plane

Observation 2 : The angular function of the orbital intersect the three axis at origin only.

Observation 3 : $R^2(r)$ v/s r curve is obtained for the orbital is



(A) $5p_z$

(B) $6d_{xy}$

(C) $6d_{x^2-y^2}$

(D) $6\ d_{yz}$

28. Question : Is the orbital of hydrogen atom $3p_x$?

STATE 1 : The radial function of the orbital is $R(r) = \frac{1}{9\sqrt{6}a_0^{3/2}}\ (4 - \sigma)\sigma\ e^{-\sigma/2}$, $\sigma = \frac{r}{2}$

STATE 2: The orbital has 1 radial node & 0 angular node.

(A) Statement (1) alone is sufficient.

(B) Statement (2) alone is sufficient

(C) Both together is sufficient

(D) Neither is sufficient

29. Consider the following nuclear reactions involving X & Y.

$X \longrightarrow Y + {}^{4}_{2}He$

$Y \longrightarrow {}_{8}O^{18} + {}_{1}H^{1}$

If both neutrons as well as protons in both the sides are conserved in nuclear reaction then identify period number of X & moles of neutrons in 4.6 g of X

(A) 3, 2.4 N_A (B) 3, 2.4 (C) 2, 4.6 (D) 3, 0.2 N_A

30. Electromagnetic radiations having λ = 310 Å are subjected to a metal sheet having work function = 12.8 eV. What will be the velocity of photoelectrons with maximum Kinetic Energy....

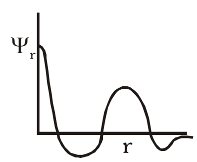
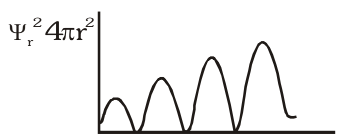
(A) 0, no emission will occur (B) 2.18 10^6 m/s

(C) $2.18\sqrt{2}$ 10^6 m/s (D) 8.72 10^6 m/s

31. If in Bohr's model, for unielectronic atom, time period of revolution is represented as $T_{n,z}$ where **n** represents shell no. and **z** represents atomic number then the value of $T_{1,2} : T_{2,1}$ will be :-

(A) 8 : 1 (B) 1 : 8 (C) 1 : 1 (D) None of these

32. Column I & Column II contain data on Schrondinger Wave-Mechanical model, where symbols have their usual meanings. Match the columns :-

Column I	Column II (Type of orbital)
(A) 	(p) 4s
(B) 	(q) $5p_x$
(C) $\Psi(\theta, \phi)$ = K (independent of θ & ϕ)	(r) 3s
(D) atleast one angular node is present	(s) $6d_{xy}$

33. Which orbital is non-directional :-

(A) s (B) p (C) d (D) All

34. A hydrogen - like atom has ground state binding energy 122.4 eV. Then :

(A) its atomic number is 3

(B) an electron of 90 eV can excite it to a higher state

(C) an 80 eV electron cannot excite it to a higher state

(D) an electron of 8.2 eV and a photon of 91.8 eV are emitted when a 100 eV electron interacts with it

35. Uncertainty in position is twice the uncertainty in momentum Uncertainty in velocity is :-

(A) $\sqrt{\frac{h}{\pi}}$ (B) $\frac{1}{2m}\sqrt{\frac{h}{\pi}}$ (C) $\frac{1}{2m}\sqrt{\hbar}$ (D) $\frac{h}{4\pi}$

36. For which orbital angular probability distribution is maximum at an angle of 45 to the axial direction :-

(A) $d_{x^2-y^2}$ (B) d_{z^2} (C) d_{xy} (D) P_x

37. Which orbit would be the first to have 'g' subshell :-

(A) 3^{rd} (B) 4^{th} (C) 5^{th} (D) 6^{th}

38. The decreasing order of energy of the 3d, 4s, 3p, 3s orbitals is :-

(A) 3d > 3s > 4s > 3p (B) 3s > 4s > 3p > 3d (C) 3d > 4s > 3p > 3s (D) 4s > 3d > 3s > 3p

39. If n and ℓ are respectively the principle and azimuthal quantum numbers, then the expression for calculating the total number of electrons in any orbit is :-

(A) $\sum_{\ell=1}^{\ell=n} 2(2\ell+1)$ (B) $\sum_{\ell=1}^{\ell=n-1} 2(2\ell+1)$ (C) $\sum_{\ell=0}^{\ell=n+1} 2(2\ell+1)$ (D) $\sum_{\ell=0}^{\ell=n-1} 2(2\ell+1)$

40. If wavelength is equal to the distance travelled by the electron in one second, then :-

(A) $\lambda = \frac{h}{p}$ (B) $\lambda = \frac{h}{m}$ (C) $\lambda = \sqrt{\frac{h}{p}}$ (D) $\lambda = \sqrt{\frac{h}{m}}$

41. According to Schrodinger model nature of electron in an atom is as :-

(A) Particles only (B) Wave only

(C) Both simultaneously (D) Sometimes waves and sometimes particle

42. Which describes orbital :-

(A) ψ (B) ψ^2 (C) $|\psi^2|\psi$ (D) All

43. In order to have the same wavelength for the electron (mass m_e) and the neutron (mass m_n) their velocities should be in the ratio (electron velocity/neutron velocity) :-

(A) m_n/m_e (B) $m_n \quad m_e$ (C) m_e/m_n (D) one

44. The quantum numbers +1/2 and –1/2 for the electron spin represent :-

(A) Rotation of the electron in clockwise and anticlockwise direction respectively.

(B) Rotation of the electron in anticlockwise and clockwise direction respectively.

(C) Magnetic moment of the electron pointing up and down respectively.

(D) Two quantum mechanical spin states which have no classifical analogue.

45. Which is true about ψ :-

(A) ψ represents the probability of finding an electron around the nucleus

(B) ψ represent the amplitude of the electron wave

(C) Both A and B

(D) None of these

46. Consider an electron in the n^{th} orbit of a hydrogen atom in the Bohr model. The circumference of the orbit can be expressed in terms of the de Broglie wavelength λ of the electron as :-

(A) (0.529) $n\lambda$ (B) $\sqrt{n}\lambda$ (C) (13.6) λ (D) $n\lambda$

47. A particle X moving with a certain velocity has a debroglie wave length of 1A . If particle Y has a mass of 25% that of X and velocity 75% that of X, debroglies wave length of Y will be :-

(A) 3 A (B) 5.33 A (C) 6.88 A (D) 48 A

48. What are the values of the orbital angular momentum of an electron in the orbitals 1s, 3s, 3d and 2p :-

(A) $0,\ 0, \sqrt{6}\hbar, \sqrt{2}\hbar$ (B) $1,\ 1, \sqrt{4}\hbar, \sqrt{2}\hbar$ (C) $0,\ 1, \sqrt{6}\hbar, \sqrt{3}\hbar$ (D) $0,\ 0, \sqrt{20}\hbar, \sqrt{6}$

49. If m = magnetic quantum number and ℓ = azimuthal quantum number then :-

(A) $m = \ell + 2$ (B) $m = 2\ell^2 + 1$ (C) $\ell = \frac{m-1}{2}$ (D) $\ell = 2m + 1$

50. The number of unpaired electrons in Mn^{4+} (Z = 25) is :-

(A) Four (B) Two (C) Five (D) Three

51. After np orbitals are filled, the next orbital filled will be :-

(A) (n + 1) s (B) (n + 2) p (C) (n + 1) d (D) (n + 2) s

52. The value of the magnetic moment of a particular ion is 2.83 Bohr magneton. The ion is :-

(A) Fe^{2+} (B) Ni^{2+} (C) Mn^{2+} (D) Co^{3+}

53. In Bohr's model of the hydrogen atom the ratio between the period of revolution of an electron in the orbit of n = 1 to the period of the revolution of the electron in the orbit n = 2 is :-

(A) 1 : 2 (B) 2 : 1 (C) 1 : 4 (D) 1 : 8

54. Let υ_1 be the frequency of the series limit of the Lyman series, υ_2 be the frequency of the first line of the lyman series, and υ_3 be the frequency of the series limit of the Balmer series :-

(A) $\upsilon_1 - \upsilon_2 = \upsilon_3$ (B) $\upsilon_2 - \upsilon_1 = \upsilon_3$ (C) $\upsilon_3 = 1/2\ (\upsilon_1 - \upsilon_3)$ (D) $\upsilon_1 + \upsilon_2 = \upsilon_3$

55. The energies of energy levels A, B and C for a given atom are in the sequence $E_A < E_B < E_C$. If the radiations of wavelengths λ_1, λ_2 and λ_3 are emitted due to the atomic transitions C to B, B to A and C to A respectively then which of the following relations is correct :-

(A) $\lambda_1 + \lambda_2 + \lambda_3 = 0$ (B) $\lambda_3 = \lambda_1 + \lambda_2^2$ (C) $\lambda_3 = \lambda_1 + \lambda_2$ (D) $\lambda_3 = \frac{\lambda_1\lambda_2}{\lambda_1 + \lambda_2}$

56. The wavelengths of photons emitted by electron transition between two similar levels in H and He^+ are λ_1 and λ_2 respectively. Then :-

(A) $\lambda_2 = \lambda_1$ (B) $\lambda_2 = 2\lambda_1$ (C) $\lambda_2 = \lambda_1/2$ (D) $\lambda_2 = \lambda_1/4$

57. If first ionization potential of an atom is 16 V, then the first excitation potential will be :-

(A) 10.2 V (B) 12 V (C) 14 V (D) 16 V

58. In which transition minimum energy is emitted :-

(A) $\infty \to 1$ (B) $2 \to 1$ (C) $3 \to 2$ (D) $n \to (n - 1)\ (n \geq 4)$

59. No. of visible lines when an electron returns from 5^{th} orbit to ground state in H spectrum :-

(A) 5 (B) 4 (C) 3 (D) 10

BRAIN TEASERS						ANSWER KEY							EXERCISE -2	
Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	D	D	B	A	B	B	C	B	B	C	D	A	C	C	B
Que.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans.	B	B	A	C	A	B	C	C	D	C	C	D	B	B	C
Que.	31	32(A)	(B)	(C)	(D)	33	34	35	36	37	38	39	40	41	42
Ans.	D	p	p,q,s	p,r	q,s	A	A,C,D	C	C	C	C	D	D	B	B
Que.	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
Ans.	A	D	B	D	B	A	C	D	A	B	D	A	D	D	B
Que.	58	59													
Ans.	D	C													

EXERCISE–03 MISCELLANEOUS TYPE QUESTIONS

TRUE / FALSE

1. The electron density in xy plane of $3d_{x^2-y^2}$ orbital is zero.
2. $3d^6$ configuration is more stable than $3d^5$.
3. The potential energy of an electron in an orbit is twice in magnitude as compared to its kinetic energy.
4. The increasing order for the values of e/m (charge/mass) for electron (e), proton (p), neutron (n) and alpha particle (α) is $n < \alpha < p < e$.
5. The orbital $3d_{xy}$ has no probability of finding electron along x and y-axis.

FILL IN THE BLANKS

1. Nitrogen has an atomic number of 7 and oxygen has an atomic number of 8. The total number of electrons in the nitrate ion (NO_3^-) is ....
2. h/π is the angular momentum of the electron in the .... orbit of He^+.
3. An emission spectrum has electromagnetic radiation of definite ....
4. The maximum number of electrons that can be accommodated in all the orbitals for which $\ell = 3$ is ....
5. The values of n_1 and n_2 in the Paschen spectral series of hydrogen atom are .... and .... respectively.

MATCH THE COLUMN

1.

	Column-I		Column-II
(A)	Aufbau principle	(p)	Line spectrum in visible region
(B)	de broglie	(q)	Orientation of an electron in an orbital
(C)	Angular momentum	(r)	Photon
(D)	Hund's rule	(s)	$\lambda = h/mv$
(E)	Balmer series	(t)	Electronic configuration
(F)	Planck's law	(u)	mvr

2.

	Column-I		Column-II
(A)	Cathode rays	(p)	Helium nuclei
(B)	dumb-bell	(q)	Uncertainty principle
(C)	Alpha particles	(r)	Electromagnetic radiation
(D)	Moseley	(s)	p-orbital
(E)	Heisenberg	(t)	Atomic number
(F)	X-ray	(u)	Electrons

3. Frequency = f, Time period = T, Energy of n^{th} orbit = E_n, radius of n^{th} orbit = r_n, Atomic number = Z, Orbit number = n :

	Column-I		Column-II
(A)	f	(p)	n^3
(B)	T	(q)	Z^2
(C)	E_n	(r)	$\frac{1}{n^2}$
(D)	$\frac{1}{r_n}$	(s)	Z

4.

	Column-I		Column-II
(A)	Lyman series	(p)	maximum number of spectral line observed = 6
(B)	Balmer series	(q)	maximum number of spectral line observed = 2
(C)	In a sample 5 $\rightarrow$ 2	(r)	2^{nd} line has wave number $\frac{8R}{9}$
(D)	In a single isolated H-atom for 3 $\rightarrow$ 1 transition	(s)	2^{nd} line has wave number $\frac{3R}{4}$
		(t)	total number of spectral line is 10

<u>ASSERTION & REASON</u>

These questions contains, Statement I (assertion) and Statement II (reason).

(A) Statement-I is true, Statement-II is true ; Statement-II is correct explanation for Statement-I.

(B) Statement-I is true, Statement-II is true ; Statement-II is NOT a correct explanation for statement-I

(C) Statement-I is true, Statement-II is false

(D) Statement-I is false, Statement-II is true

1. **Statement-I** : Nodal plane of p_x atomic orbital is yz plane.
Because
Statement-II : In p_x atomic orbital electron density is zero in the yz plane.

2. **Statement-I** : No two electrons in an atom can have the same values of four quantum numbers.
Because
Statement-II : No two electrons in an atom can be simultaneously in the same shell, same subshell, same orbitals and have same spin.

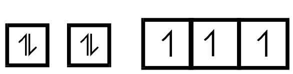
3. **Statement-I** : p-orbital has dumb-bell shape.
Because
Statement-II : Electrons present in p-orbital can have one of three values for 'm', i.e. 0, +1, –1

4. **Statement-I** : The ground state configuration of Cr is $3d^5\ 4s^1$.
Because
Statement-II : A set of exactly half filled orbitals containing parallel spin arrangement provide extra stability.

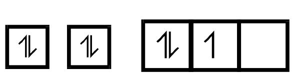
5. **Statement-I** : Mass numbers of most of the elements are fractional.
Because
Statement-II : Mass numbers are obtained by comparing with the mass number of carbon taken as 12.

6. **Statement-I** : Limiting line in the balmer series has a wavelength of 36.4 μm.
Because
Statement-II : Limiting lines is obtained for a jump of electron from n = ∞ to n = 2 for Balmer series.

7. **Statement-I** : The electronic configuration of nitrogen atom is represented as :



not as



Because
Statement-II : The configuration of ground state of an atom is the one which has the greatest multiplicity.

8. **Statement-I** : The configuration of B atom cannot be $1s^2\ 2s^3$.

Because

Statement-II : Hund's rule demands that the configuration should display maximum multiplicity.

9. **Statement-I** : 2p orbitals do not have spherical nodes.

Because

Statement-II : The number of spherical nodes in p-orbitals is given by (n − 2).

10. **Statement-I** : In Rutherford's gold foil experiment, very few $\alpha-$ particles are deflected back.

Because

Statement-II : Nucleus present inside the atom is heavy.

11. **Statement-I** : Each electron in an atom has two spin quantum numbers.

Because

Statement-II : Spin quantum numbers are obtained by solving Schrodinger wave equation.

12. **Statement-I** : There are two spherical nodes in 3s-orbital.

Because

Statement-II : There is no angular node in 3s-orbital.

COMPREHENSION BASED QUESTIONS

Comprehension # 1

Read the following rules and answer the questions at the end of it.

- Electrons in various suborbits of an orbit are filled in increasing order to their energies.
- Pairing of electrons in various orbitals of a suborbit takes place only after each orbital is half-filled.
- No two electrons in an atom can have the same set of quantum number.

1. Cr (Z = 24), Mn^+ (Z = 25), Fe^{2+} (Z = 26) and Co^{3+} (Z = 27) are isoelectronic each having 24 electrons. Thus,

(A) all have configurations as [Ar] $4s^1\ 3d^5$

(B) Cr and Mn^+ have configurations as [Ar] $4s^1\ 3d^5$ while Fe^{2+} and Co^{3+} have configurations as [Ar]$3d^5$.

(C) all have configurations as [Ar] $3d^6$

(D) all have configurations as [Ar] $4s^2\ 3d^6$

2. A compound of vanadium has a magnetic moment of 1.73 BM. Electronic configuration of the vanadium ion in the compound is :

(A) [Ar] $4s^0\ 3d^1$ (B) [Ar] $4s^2\ 3d^3$ (C) [Ar] $4s^1\ 3d^0$ (D) [Ar] $4s^0\ 3d^5$

3. Which of these ions are expected to be paramagnetic and coloured in aqueous solution ?

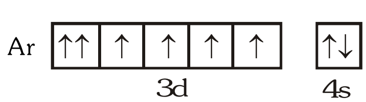
(A) Fe^{3+}, Ti^{3+}, Co^{3+} (B) Cu^+, Ti^{4+}, Sc^{3+} (C) Fe^{3+}, Ni^{2+}, V^{5+} (D) Cu^+, Cu^{2+}, Fe^{2+}

4. While writing the following electronic configuration of Fe some rules have been violated :

I : Aufbau rule,

II : Hund's rule

III : Pauli's exclusion principle



(A) I, II (B) II, III (C) I, III (D) I, II, III

5. How many elements would be in the second period of the periodic table if the spin quantum number (m_s) could have the value of $-\frac{1}{2}, 0, +\frac{1}{2}$?

(A) 8 (B) 10 (C) 12 (D) 18

6. The sub-shell that arises after *f* sub-shell is called g sub-shell.

(A) it contains 18 electrons and 9 orbitals

(B) it corresponds to ℓ = 4 and first occurs in 5th energy level

(C) a g-orbital can have maximum of two electrons

(D) all the above statements are true.

MISCELLANEOUS TYPE QUESTION | **ANSWER KEY** | EXERCISE -3

- ***True / False***

1. F 2. F 3. T 4. T 5. T

- ***Fill in the Blanks***

1. 32 2. 2^{nd} 3. frequency or wavelength 4. 14 5. 3, (4, 5, 6,....)

- ***Match the Column***

1. (A) $\rightarrow$ t; (B) $\rightarrow$ s ; (C) $\rightarrow$ u ; (D) $\rightarrow$ q ; (E) $\rightarrow$ p; (F) $\rightarrow$ r

2. (A) $\rightarrow$ u ; (B) $\rightarrow$ s ; (C) $\rightarrow$ p ; (D) $\rightarrow$ t ; (E) $\rightarrow$ q ; (F) $\rightarrow$ r

3. (A) $\rightarrow$ q ; (B) $\rightarrow$ p ; (C) $\rightarrow$ q,r ; (D) $\rightarrow$ r,s

4. (A) $\rightarrow$ r ; (B) $\rightarrow$ s; (C) $\rightarrow$ p; (D) $\rightarrow$ q

- ***Assertion - Reason Questions***

1. A 2. A 3. B 4. A 5. E 6. A
7. A 8. B 9. A 10. B 11. E 12. B

- ***Comprehension Based Questions***

Comprehension #1 : 1. (B) 2. (A) 3. (A) 4. (D) 5. (C) 6. (D)

EXERCISE–04 [A] CONCEPTUAL SUBJECTIVE EXERCISE

1. How long would it take a radio wave of frequency $6 \quad 10^{3}\ sec^{-1}$ to travel from mars to the earth, a distance of $8 \quad 10^{7}$ km ?

2. The energy levels of hypothetical one electron atom are shown below.

0 eV —— n = ∞

–0.50 eV —— n = 5

–1.45 eV —— n = 4

–3.08 eV —— n = 3

–5.3 eV —— n = 2

–15.6 eV —— n = 1

(a) Find the ionisation potential of atom?

(b) Find the short wavelength limit of the series terminating at n = 2 ?

(c) Find the wave no. of photon emitted for the transition made by the electron from third orbit to first orbit ?

(d) Find the minimum energy that an electron will have after interacting with this atom in the ground state, if the initial kinetic energy of the electron is (i) 6eV (ii) 11 eV ?

3. Suppose 10^{-17} J of light energy is needed by the interior of the human eye to see an object. How many photons of green light (λ = 550 nm) are needed to generate this minimum amount of energy?

4. Find the number of photons of radiation of frequency $5 \quad 10^{13}\ s^{-1}$ that must be absorbed in order to melt one g ice when the latent heat of fusion of ice is 330 J/g.

5. The eyes of certain member of the reptile family pass a single visual signal to the brain when the visual receptors are struck by photons of wavelength 850 nm. If a total energy of $3.15 \quad 10^{-14}$ J is required to trip the signal, what is the minimum number of photons that must strike the receptor?

6. The wavelength of a certain line in the Paschen series is 1093.6 nm. What is the value of n_{high} for this line [$R_H = 1.0973 \quad 10^{+7}\ m^{-1}$].

7. Wavelength of the Balmer H_α line (first line) is 6565 Å. Calculate the wavelength of H_β (second line).

8. Calculate the Rydberg constant R if He^{+} ions are known to have the wavelength difference between the first (of the longest wavelength) lines of Balmer and Lyman series equal to 133.7 nm.

9. Calculate the energy emitted when electrons of 1.0 g atom of hydrogen undergo transition giving the spectral line of lowest energy in the visible region of its atomic spectrum.

10. A photon having λ = 854 Å causes the ionization of a nitrogen atom. Give the I.E. per mole of nitrogen in KJ.

11. Calculate energy of electron which is moving in the orbit that has its radius, Sixteen times the radius of first Bohr orbit for H-atom.

12. The electron energy in hydrogen atom is given by $E_n = \dfrac{-21.7\times10^{-12}}{n^2}$ ergs. Calculate the energy required to remove an e^- completely from n = 2 orbit. What is the largest wavelength in cm of light that can be used to cause this transition.

13. Calculate the wavelength in angstrom of photon that is emitted when an e^- in Bohr orbit n = 2 returns to the orbit n = 1. The ionization potential of the ground state of hydrogen atom is 2.17×10^{-11} erg/atom.

14. The velocity of e^- in a certain Bohr orbit of the hydrogen atom bears the ratio 1 : 275 to the velocity of light. What is the quantum no. "n" of the orbit and the wave no. of the radiation emitted for the transition form the quantum state (n + 1) to the ground state.

15. A doubly ionised lithium atom is hydrogen like with atomic number Z = 3. Find the wavelength of the radiation required to excite the electron in Li^{2+} from the first to the third Bohr orbit.

16. Estimate the difference in energy between I and II Bohr Orbit for a hydrogen atom. At what minimum At. no. a transition from n = 2 to n = 1 energy level would result in the emission of X-rays with $\lambda = 3.0 \times 10^{-8}$ m? Which hydrogen like species does this At. no. correspond to:

17. 1.8 g atoms of hydrogen are excited to radiations. The study of spectra indicates that 27% of the atoms are in 3rd energy level and 15% of atoms in 2nd energy level and the rest in ground state. If I.P. of H is 21.7×10^{-12} erg. Calculate.

(i) No. of atoms present in III & II energy level.

(ii) Total energy evolved when all the atoms return to ground state.

18. One mole He^+ ions are excited. Spectral analysis showed existence of 50% ions in 3rd orbit, 25% in 2nd and rest in ground state. Calculate total energy evolved when all the ions return to the ground state.

19. The energy of an excited H-atom is –3.4 eV. Calculate angular momentum of e^-.

20. The vapours of Hg absorb some electrons accelerated by a potential difference of 4.5 volt as a result of it light is emitted. If the full energy of single incident e^- is supposed to be converted into light emitted by single Hg atom, find the wave no. of the light.

21. The hydrogen atom in the ground state is excited by means of monochromatic radiation of wavelength x A^0. The resulting spectrum consists of 15 different lines. Calculate the value of x.

22. If the average life time of an excited state of H atom is of order 10^{-8} sec, estimate how many orbits an e^- makes when it is in the state n = 2 and before it suffers a transition to n = 1 state.

23. Calculate the frequency of e^- in the first Bohr orbit in a H-atom.

24. A single electron orbits around a stationary nucleus of charge +Ze where Z is a constant from the nucleus and e is the magnitude of the electric charge. The hydrogen like species required 47.2 eV to excite the electron from the second Bohr orbit to the third Bohr orbit. Find -

(i) the value of Z give the hydrogen like species formed.

(ii) the kinetic energy and potential energy of the electron in the first Bohr orbit.

25. A stationary He^+ ion emitted a photon corresponding to a first line of the Lyman series. The photon liberated a photoelectron from a stationary H atom in ground state. What is the velocity of photoelectron ?

26. To what series does the spectral lines of atomic hydrogen belong if its wave number is equal to the difference between the wave number of the following two lines of the Balmer series 486.1 and 410.2 nm. What is the wavelength of this ?

27. A particle of charge equal to that of an electron and mass 208 times the mass of the electron moves in a circular orbit around a nucleus of charge +3e. Assuming that the Bohr model of the atom is applicable to this system, (a) derive an expression for the radius of the n^{th} bohr orbit, (b) find the value of n for which the radius of the orbit is approximately the same as that of the first Bohr orbit for the hydrogen atom, and (c) find the wavelength of the radiation emitted when the revolving particle jumps from the third orbit to the first.

28. A neutrons breaks into a proton and an electron. This decay of neutron is accompanied by release of energy. Assuming that 50% of the energy is produced in the form of electromagnetic radiation, what will be the frequency of radiation produced. Will this photon be sufficient to cause ionization of Aluminium. In case it is able to do so what will be the energy of the electron ejected from the Aluminum atom. IE_1 of Al = 577 kJ/mol.

29. Calculate the threshold frequency of metal if the binding energy is 180.69 kJ mol^{-1} of electron.

30. Calculate the binding energy per mole when threshold wavelength of photon is 240 nm.

31. A metal was irradiated by light of frequency $3.2 \quad 10^{15}\ s^{-1}$. The photoelectron produced had its KE, 2 times the KE of the photoelectron which was produced when the same metal was irradiated with a light of frequency $2.0 \quad 10^{15}\ s^{-1}$. What is work function ?

32. U.V. light of wavelength 800 A & 700 A falls on hydrogen atoms in their ground state & liberates electrons with kinetic energy 1.8 eV and 4 eV respectively. Calculate planck's constant.

33. A potential difference of 20 kV is applied across an X-ray tube. Find the minimum wavelength of X-ray generated.

34. The K.E. of an electron emitted from tungsten surface is 3.06 eV. What voltage would be required to bring the electron to rest.

35. What is de-Broglie wavelength of a He-atom in a container at room temperature. $\left(\text{Use } U_{avg.} = \sqrt{\dfrac{8kT}{\pi m}}\right)$

36. Through what potential difference must an electron pass to have a wavelength of 500 A .

37. A proton is accelerated to one tenth of the velocity of light. If its velocity can be measured with a precision ± 1%. What must be its uncertainty in position ?

38. To what effective potential a proton beam be subjected to give its protons a wavelength of $1 \quad 10^{-10}$m.

39. Calculate the number of exchange pairs of electrons present in configuration of Cu according to Aufbau principle considering 3d orbitals.

40. He atom can be excited to $1s^1\ 2p^1$ by λ = 58.44 nm. If lowest excited state for He lies 4857 cm^{-1} below the above. Calculate the energy for the lower excitation state.

41. A certain dye absorbs 4530 A and fluoresence at 5080 A these being wavelengths of maximum absorption that under given conditions 47% of the absorbed energy is emitted. Calculate the ratio of the no. of quanta emitted to the number absorbed.

42. The reaction between H_2 and Br_2 to form HBr in presence of light is initiated by the photo decomposition of Br_2 into free Br atoms (free radicals) by absorption of light. The bond dissociation energy of Br_2 is 192 kJ/mole. What is the longest wavelength of the photon that would initiate the reaction?

43. The quantum yield for decomposition of HI is 0.2. In an experiment 0.01 moles of HI are decomposed. Find the number of photons absorbed.

44. Calculate the wavelength of the radiation that would cause photo dissociation of chlorine molecule if the Cl – Cl bond energy is 243 kJ/mol.

45. The dissociation energy of H_2 is 430.53 kJ/mol. If H_2 is exposed to radiant energy of wavelength 253.7 nm, what % of radiant energy will be converted into K.E ?

46. Iodine molecule dissociates into atoms after absorbing light of 4500 A^0 If one quantum of radiation is absorbed by each molecule, calculate the K.E. of iodine atoms.
(Bond energy of I_2 = 240 kJ/mol)

47. X-rays emitted from a copper target and a molybdenum target are found to contain a line of wavelength 22.85 nm attributed to the K_α line of an impurity element. The K_α lines of a copper (Z = 29) and molybdenum (Z = 42) have wavelength 15.42 nm and 7.12 nm respectively. Using Moseley's law, $\gamma^{1/2}$ = a (Z – b). Calculate the atomic number of the impurity element.

48. What is de-Broglie wavelength associated with an e^- accelerated through P.D. = 100 kV ?

49. Calculate the de-broglie wavelength associated with motion of earth (mass 6 10^{24} kg) orbiting around the sun at a speed of 3 10^6 m/s.

50. A base ball of mass 200 g is moving with velocity 30 10^2 cm/s. If we can locate the base ball with error equal in magnitude to the λ of the light used (5000 Å), how will the uncertainty in momentum compared with the total momentum of base ball ?

51. An electron has a speed of 40 m/s, accurate up 99.99 %. What is the uncertainty in locating position?

CONCEPTUAL SUBJECTIVE EXERCISE **ANSWER KEY** EXERCISE-4(A)

1. 2.66 10^2sec **2.** (a) 15.6 eV (b) 233.9 nm, (c) 1.008 10^7 m^{-1}
(d) (i) electron will not interact (ii) 0.7 eV

3. 28 photons **4.** 10^{22} **5.** 1.35 10^5 **6.** 6 **7.** 4863 A

8. 1.096 10^7 m^{-1} **9.** 1.827 10^5 J/mol **10.** 1403 kJ/mol **11.** –1.36 10^{-19} Joules

12. 5.425 10^{-12} ergs, 3.7 10^{-5} cm **13.** 1220 A **14.** 2 ; 9.75 10^4 cm^{-1}

15. 113.74 A **16.** 10.2 eV, Z=2 **17.** 292.68 10^{21} atoms, 162.60 10^{21} atoms, 832.50 kJ

18. 331.13 10^4J **19.** h/π **20.** 3.63 $10^6 m^{-1}$ **21.** 938 A

22. 8 10^6 **23.** 6530 10^{12} Hz **24.** (i) Z = 5, (ii) 340 eV, –680 eV

25. 3.09 10^8 cm/sec **26.** Brackett ; 2.63 10^{-4} cm

27. $r_n = \dfrac{n^2h^2}{4K\pi^2 \times 3e^2 \times 208m_e}$; n = 25 ; 55.2 pm **28.** 9.15 10^{19} Hz, yes, 58.5 10^{-15} J

29. 4.5 10^{14} s^{-1} **30.** 497 kJ/mol **31.** 319.2 kJ/mol **32.** 6.57 10^{-34} Js

33. 0.62 A **34.** 3.06 V **35.** 0.79 A **36.** 6.03 10^{-4}volt

37. 1.05 10^{-13}m **38.** 0.0826 volts **39.** 16 **40.** 3.3 10^{-18} J

41. 0.527 **42.** 6235 A **43.** 3 10^{22} **44.** 4.9 10^{-7} m

45. 8.68 % **46.** 2.186 10^{-20} Joules **47.** 24 **48.** 3.88 pm

49. 3.68 10^{-65} m **50.** 1.75 10^{-29} **51.** 0.0144 m

EXERCISE–04 [B] BRAIN STORMING SUBJECTIVE EXERCISE

1. To what series does the spectral lines of atomic hydrogen belong if its wave number is equal number is equal to the difference between the wave numbers of the following two lines of the Balmer series 486.1 and 410.2 nm? What is the wavelength of this line ?

2. Energy required for the excitation of H-atom its ground state to the 2^{nd} excited state is 2.67 times smaller than dissociation energy of H_2(g). If H_2 (g) placed in 1.0 litre flask at 27 Cand 1.0 bar is to be excited to their 2^{nd} excited state, what will be the total energy consumption ?

3. Find the quantum number 'n' corresponding to the excited state of He^+ ion if on transition to the ground state that ion emits two photons in succession with wavelengths 108.5 and 30.4 nm.

4. A gas of identical H-like atom has some atoms in the lowest (ground) energy level A and some atoms in a particular upper (excited) energy level B and there are no atoms in any other energy level. The atoms of the gas make transition to a higher energy level by absorbing monochromatic light of photon energy 2.7 eV. Subsequently, the atoms emit radiation of only six different photons energies. Some of the emitted photons have energy 2.7 eV. Some have more and some have less than 2.7 eV.

(a) Find the principal quantum number of initially excited level B.

(b) Find the ionisation energy for the gas atoms.

(c) Find the maximum and the minimum energies of the emitted photons.

5. A hydrogen like atom (atomic number Z) is in a higher excited state of quantum number n. This excited atom can make a transition to the first excited state by successively emitting two photons of energies 10.20 eV and 17.00 eV respectively. Alternatively, the atom from the same excited state can make a transition to the second excited state by successively emitting two photons of energy 4.25 eV and 5.95 eV respectively. Determine the values of n and z (ionisation energy of hydrogen atom = 13.6 eV).

6. Hydrogen atom in its ground state is excited by means of monochromatic radiation of wavelength 975 A . How many different lines are possible in the resulting spectrum? Calculate the longest wavelength amongst them.

7. An alpha particle after passing through a potential difference of $2 \quad 10^6$ volt falls on a silver foil. The atomic number of silver is 47. Calculate (i) the K.E. of the alpha-particle at the time of falling on the foil. (ii) K.E. of the α-particle at a distance of $5 \quad 10^{-14}$ m from the nucleus, (iii) the shortest distance from the nucleus of silver to which the α-particle reaches.

8. Suppose the potential energy between electron and proton at a distance r is given by $-\frac{ke^2}{3r^3}$. Use Bohr's theory to obtain energy of such a hypothetical atom.

9. An energy of 68 eV is required to excite a hydrogen like atom from its second Bohr orbit to the third. The nuclear charge is Ze. Find the value of Z, the kinetic energy of the electron in the first Bohr orbit and the wavelength of the radiation required to eject the electrons from the first Bohr orbit to infinity .

10. The ionisation energy of a H-like Bohr atom is 4 Rydbergs.

(i) What is the wavelength of radiation emitted when the e^- jumps from the first excited state to the ground state?

(ii) What is the radius of first Bohr orbit for this atom? [1 Rydberg = $2.18 \quad 10^{-18}$ J]

11. Photon having wavelength 12.4 nm was allowed to strike a metal plate having work function 25 eV. Calculate the -

(a) Maximum kinetic energy of photoelectrons emitted in eV.

(b) Wavelength of electron with maximum kinetic energy in A .

(c) Calculate the uncertainity in wavelength of emitted electron, if the uncertainity in the momentum is $6.62 \quad 10^{-28}$ kg m/sec.

12. Electron present in single electron species jumps from energy level 3 to 1. Emitted photons when passed through a sample containing excited He^{+} ion causes further excitation to some higher energy level (Given $E_n = 13.6 \frac{Z^2}{n^2})$: Determine .

(i) Atomic number of single electron species.

(ii) Principal quantum number of initial excited level & higher energy of He^{+}

13. The angular momentum of an electron in a Bohr's orbit of H-atom is $3.1652 \quad 10^{-34}$ kg-m^2/sec. Calculate the wave number in terms of Rydberg constant (R) of the spectral line emitted when an electron falls from this level to the ground state. (Use $h = 6.626 \quad 10^{-34}$ Js).

BRAIN STORMING SUBJECTIVE EXERCISE **ANSWER KEY** EXERCISE-4(B)

1.	$n_1 = 4$, $n_2 = 6$, $2.63 \quad 10^{-4}$ cm	**2.**	21.8 kJ
3.	n = 5	**4.**	(a) n = 2, (b) 14.4 eV, (c) 13.5eV, 0.7eV
5.	n = 6, Z = 3	**6.**	six, 18800 A
7.	$6.4 \quad 10^{-13}$ J, $2.1 \quad 10^{-13}$ J, $3.4 \quad 10^{-14}$m	**8.**	$E = \frac{n^6h^6}{384m^3K^2e^4\pi^6}$
9.	6 ; 489.6 eV, 25.28 A	**10.**	300.89 A , $2.645 \quad 10^{-9}$ cm
11.	(a) 75 eV ; (b) 1.414 A ; (c) $2 \quad 10^{-14}$ m		
12.	(i) Z = 1 (ii) For He^{+} ion this energy corresponds to excitation from 2 to 6.		
13.	$R\left(\frac{8}{9}\right)$		

EXERCISE - 05 [A] JEE-[MAIN] : PREVIOUS YEAR QUESTIONS

1. An atom has a mass of 0.02 kg and uncertainty in its velocity is 9.218 10^{-6} m/s then uncertainty in position is (h = 6.626 10^{-34} Js) [AIEEE 2002]
(1) 2.86 10^{-28} m (2) 2.86 10^{-32} cm (3) 1.5 10^{-27} m (4) 3.9 10^{-10} m

2. Energy of H- atom in the ground state is –13.6 eV, Hence energy in the second excited state is- [AIEEE 2002]
(1) –6.8 eV (2) –3.4 eV (3) –1.51 eV (4) –4.3 eV

3. Uncertainty in position of a particle of 25 g in space is 10^{-5} m. Hence uncertainty in velocity (ms^{-1}) is (Planck's constant h = 6.6 10^{-34} Js) [AIEEE-2002]
(1) 2.1 10^{-28} (2) 2.1 10^{-34} (3) 0.5 10^{-34} (4) 5.0 20^{-24}

4. 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 [AIEEE-2003]
(1) $\sqrt{2}.\frac{h}{2\pi}$ (2) $+\frac{1}{2}.\frac{h}{2\pi}$ (3) zero (4) $\frac{h}{2\pi}$

5. The number of d-electrons retained in Fe^{2+} (At. no. of Fe = 26) ion is : [AIEEE-2003]
(1) 6 (2) 3 (3) 4 (4) 5

6. The de Broglie wavelength of a tennis ball of mass 60 g moving with a velocity of 10 metres per second is approximately : [AIEEE 2003]
(1) 10^{-25} metres (2) 10^{-33} metres (3) 10^{-31} metres (4) 10^{-16} metres

7. 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 ? [AIEEE-2003]
(1) $2 \rightarrow 5$ (2) $3 \rightarrow 2$ (3) $5 \rightarrow 2$ (4) $4 \rightarrow 1$

8. Which of the following sets of quantum number is correct for an electron in 4f orbital ? [AIEEE-2004]
(1) n = 3, l = 2, m = – 2, s = $+\frac{1}{2}$ (2) n = 4, l = 4, m = – 4, s = $-\frac{1}{2}$
(3) n = 4, l = 3, m = + 1, s = $+\frac{1}{2}$ (4) n = 4, l = 3, m = + 4, s = $+\frac{1}{2}$

9. Consider the ground state of Cr atom (Z = 24). The numbers of electrons with the azimuthal quantum numbers, l = 1 and 2 are, respectively [AIEEE-2004]
(1) 16 and 5 (2) 12 and 5 (3) 16 and 4 (4) 12 and 4

10. The wavelength of the radiation emitted, when in a hydrogen atom electron falls from infinity to stationary state 1, would be [AIEEE-2004]
(Rydberg constant = 1.097 10^{7} m^{-1}) :
(1) 9.1 10^{-8} nm (2) 192 nm (3) 406 nm (4) 91 nm

11. Which one of the following sets of ions represents the collection of isoelectronic species ? [AIEEE-2004]
(1) Na^+, Mg^{2+}, Al^{3+}, Cl^- (2) Na^+, Ca^{2+}, Sc^{3+}, F^-
(3) K^+, Cl^-, Mg^{2+}, Sc^{3+} (4) K^+, Ca^{2+}, Sc^{3+}, Cl^-

12. In a multi-electron atom, which of the following orbitals described by the three quantum members will have the same energy in the absence of magnetic and electric fields ? [AIEEE-2005]
(A) n = 1, l = 0, m = 0 (B) n = 2, l = 0, m = 0
(C) n = 2, l = 1, m = 1 (D) n = 3, l = 2, m = 1
(E) n = 3, l = 2, m = 0
(1) (D) and (E) (2) (C) and (D) (3) (B) and (C) (4) (A) and (B)

13. Of the following sets which one does not contain isoelectronic species ? **[AIEEE-2005]**

(1) BO_3^{3-}, CO_3^{2-}, NO_3^- (2) SO_3^{2-}, CO_3^{2-}, NO_3^- (3) CN^-, N_2, C_2^{2-} (4) PO_4^{3-}, SO_4^{2-}, ClO_4^-

14. Which of the following statements in relation to the hydrogen atom is correct ? **[AIEEE-2005]**

(1) 3s, 3p and 3d orbitals all have the same energy

(2) 3s and 3p orbitals are of lower energy than 3d orbitals

(3) 3p orbital is lower in energy than 3d orbital

(4) 3s orbitals is lower in energy than 3p orbital

15. According to Bohr's theory angular momentum of electron in 5^{th} shell is :- **[AIEEE-2006]**

(1) 1.0 h/π (2) 10 h/π (3) 2.5 h/π (4) 25 h/π

16. Uncertainty in the position of an electron (mass = $9.1 \quad 10^{-31}$ Kg) moving with a velocity 300 ms^{-1}, accurate upto 0.001%, will be :- (h = $6.63 \quad 10^{-34}$ Js) **[AIEEE-2006]**

(1) $5.76 \quad 10^{-2}$ m (2) $1.92 \quad 10^{-2}$ m (3) $3.84 \quad 10^{-2}$ m (4) $19.2 \quad 10^{-2}$ m

17. Which of the following sets of quantum numbers represents the highest energy of an atom ? **[AIEEE-2007]**

(1) n = 3, l = 1, m =1, s = +½ (2) n = 3, l = 2, m =1, s = +½

(3) n = 4, l = 0, m =0, s = +½ (4) n = 3, l = 0, m =0, s = +½

18. Which one of the following constitutes a group of the isoelectronic species? **[AIEEE-2008]**

(1) C_2^{2-}, O_2^-, CO, NO (2) $NO^+, C_2^{2-}, CN^-, N_2$ (3) $CN^-, N_2, O_2^{2-}, C_2^{2-}$ (4) N_2, O_2^-, NO^+, CO

19. The ionziation enthalpy of hydrogen atom is 1.312 x 10^6 J mol^{-1}. The energy required to excite the electron in the atom from n =1 to n =2 is **[AIEEE-2008]**

(1) 8.51 x 10^5 J mol^{-1} (2) 6.56 x 10^5 J mol^{-1} (3) 7.56 x 10^5 J mol^{-1} (4) 9.84 x 10^5 J mol^{-1}

20. In an atom, an electron is moving with a speed of 600 m/s with an accuracy of 0.005%. Certainity with which the position of the electron can be located is (h = $6.6 \quad 10^{-34}$ kg m^2 s^{-1}, mass of electron, e_m = $9.1 \quad 10^{-31}$ kg):- **[AIEEE-2009]**

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

21. Calculate the wavelength (in nanometer) associated with a proton moving at $1.0 \quad 10^3$ ms^{-1} (Mass of proton = $1.67 \quad 10^{-27}$ kg and h = $6.63 \quad 10^{-34}$ Js) :- **[AIEEE-2009]**

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

22. 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 = $3 \quad 10^8$ ms^{-1} and N_A = $6.02 \quad 10^{23}$ mol^{-1}) **[AIEEE-2010]**

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

23. Ionisation energy of He^+ is $19.6 \quad 10^{-18}$ J $atom^{-1}$. The energy of the first stationary state (n = 1) of Li^{2+} is:- **[AIEEE-2010]**

(1) $8.82 \quad 10^{-17}$ J $atom^{-1}$ (2) $4.41 \quad 10^{-16}$ J $atom^{-1}$

(3) $-4.41 \quad 10^{-17}$ J $atom^{-1}$ (4) $-2.2 \quad 10^{-15}$ J $atom^{-1}$

24. 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 :- **[AIEEE-2011]**

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

25. 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 :- **[AIEEE-2011]**

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

26. The increasing order of the ionic radii of the given isoelectronic species is :- **[AIEEE-2012]**

(1) K^+, S^{2-}, Ca^{2+} , Cl^- (2) Cl^-, Ca^{2+}, K^+, S^{2-} (3) S^{2-}, Cl^-, Ca^{2+}, K^+ (4) Ca^{2+}, K^+, Cl^-, S^{2-}

27. The electrons identified by quantum numbers n and ℓ :- **[AIEEE-2012]**

(a) $n = 4, \ell = 1$ (b) $n = 4, \ell = 0$ (c) $n = 3, \ell = 2$ (d) $n = 3, \ell = 1$

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)

PREVIOUS YEARS QUESTIONS **ANSWER KEY** EXERCISE-5 [A]

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans	1	3	1	3	1	2	3	3	2	4	4	1	2	1	3
Que.	16	17	18	19	20	21	22	23	24	25	26	27			
Ans	2	2	2	4	1	4	1	3	1	2	4	3			

EXERCISE - 05 [B] JEE-[ADVANCED] : PREVIOUS YEAR QUESTIONS

1. Rutherfords experiment , which established the nuclear model of atom, used a beam of :–

   (A) β - particles, which impinged on a metal foil and get absorbed. **[JEE 2002]**

   (B) γ - rays, which impinged on a metal foil and ejected electron.

   (C) Helium atoms, which impinged on a metal foil and got scattered.

   (D) Helium nuclie, which impinged on a metal foil and got scattered.

2. The magnetic moment of cobalt of the compund $Hg[Co(SCN)_4]$ is [Given : Co^{+2}] **[JEE 2004]**

   (A) $\sqrt{3}$ (B) $\sqrt{8}$ (C) $\sqrt{15}$ (D) $\sqrt{24}$

3. The radius of which of the following orbit is same as that of the first Bohr's orbit of hydrogen atom? **[JEE 2004]**

   (A) He^{+} (n = 2) (B) Li^{2+} (n = 2) (C) Li^{2+} (n = 3) (D) Be^{3+} (n = 2)

4. (a) The Schrodinger wave equation for hydrogen atom is **[IIT-2004]**

$$\psi_{2s} = \frac{1}{4(2\pi)^{1/2}}\left(\frac{1}{a_0}\right)^{3/2}\left(2 - \frac{r_0}{a_0}\right)e^{-r/a}$$

   Where a_0 is Bohr's radius. Let the rdial node in 2s be at r_0. Then find r_0 in terms of a_0.

   (b) A base ball having mass 100 g moves with velocity 100 m/s. Find out the value of wavelength of base ball.

5. (a) Calculate velocity of electron in first Bohr orbit of hydrogen atom (Given $r = a_0$) **[IIT-2005]**

   (b) Find de-Broglie wavelength of the electron in first Bohr orbit.

   (c) Find the orbital angular momentum of 2p-orbital in terms of $h/2\pi$ units.

6. Given in hydrogenic atom r_n, V_n, E, K_n stand for radius, potential energy, total energy and kinetic energy in n^{th} orbit. Find the value of U,v,x,y. **[JEE 2006]**

(A)	$U = \frac{V_n}{K_n}$	(P)	1
(B)	$\frac{1}{r_n} \propto E^x$	(Q)	–2
(C)	$r_n \propto Z^y$ (Z = Atomic number)	(R)	–1
(D)	v = (Orbital angular momentum of electron in its lowest energy)	(S)	0

7. Match the entries in **Column I** with the correctly related quantum number(s) in **Column II**. Indicate your answer by darkening the appropriate bubbles of the 4 4 matrix given in the ORS. **[JEE 2008]**

	Column I		Column II
(A)	Orbital angular momentum of the electron in a hydrogen-like atomic orbital	(P)	Principal quantum number
(B)	A hydrogen-like one-electron wave function obeying Pauli principle	(Q)	Azimuthal quantum number
(C)	Shape, size and orientation of hydrogen like atomic orbitals	(R)	Magnetic quantum number
(D)	Probability density of electron at the nucleus in hydrogen-like atom	(S)	Electron spin quantum number

(A)

Paragraph for questions 8 to 10 **[JEE 2010]**

The hydrogen-like species Li^{2+} is in a spherically symmetric state S_1 with one radial node. Upon absorbing light the ion undergoes transition to a state S_2. The state S_2 has one radial node and its energy is equal to the ground state energy of the hydrogen atom.

8. The state S_1 is :-

(A) 1s (B) 2s (C) 2p (D) 3s

9. Energy of the state S_1 in units of the hydrogen atom ground state energy is :-

(A) 0.75 (B) 1.50 (C) 2.25 (D) 4.50

10. The orbital angular momentum quantum number of the state S_2 is :-

(A) 0 (B) 1 (C) 2 (D) 3

11. The maximum number of electrons that can have principal quantum number, n=3, and spin quantum number, $m_s = -1/2$, is **[JEE 2011]**

12. The work function (ϕ) of some metals is listed below. The number of metals which will show photoelectric effect when light of 300 nm wavelength falls on the metal is :- **[JEE 2011]**

Metal	Li	Na	K	Mg	Cu	Ag	Fe	Pt	W
ϕ(eV)	2.4	2.3	2.2	3.7	4.8	4.3	4.7	6.3	4.75

13. The kinetic energy of an electron in the second Bohr orbit of a hydrogen atom is [a_0 is Bohr radius] **[JEE 2012]**

(A) $\frac{h^2}{4\pi^2 m a_0^2}$ (B) $\frac{h^2}{16\pi^2 m a_0^2}$ (C) $\frac{h^2}{32\pi^2 m a_0^2}$ (D) $\frac{h^2}{32\pi^2 m a_0^2}$

PREVIOUS YEARS QUESTIONS **ANSWER KEY** EXERCISE-5 [B]

1. (D) **2.** (C) **3.** (D) **4.** (a) $\mathbf{r_0 = 2a_0}$ (b) $\mathbf{6.626 \times 10^{-25}}$ **Å**

5. (a) $\mathbf{2.197 \times 10^6}$ **m/s** (b) **3.31 Å** (c) $\sqrt{2}.\frac{h}{2\pi}$ **6.** (A) Q, (B) P, (C) R, (D) S

7. (A) Q,R (B) P, Q, R,S (C) P, Q, R (D) P, Q **8.** (B) **9.** (C)

10. (B) **11.** 9 **12.** 4 **13.** **(C)**