विध्न विचारत भीरु जन, नहीं आरम्भे काम, विपति देख छोड़े तुरंत मध्यम मन कर श्याम।
पुरुष सिंह संकल्प कर, सहते विपति अनेक, 'बना' न छोड़े ध्येय को, रघुबर राखे टेक।।

रचितः मानव धर्म प्रणेता

सद्गुरु श्री रणछोड़दासजी महाराज

STUDY PACKAGE

This is TYPE 1 Package plese Wait for Type 2

Subject : CHEMISTRY

Topic : Atomic Structure

TEKO CLASSES ®

.....the support

Index

1. Key Concepts
2. Exercise I
3. Exercise II
4. Exercise III
5. Exercise IV
6. Answer Key
7. 34 Yrs. Que. from IIT-JEE
8. 10 Yrs. Que. from AIEEE

Student's Name :______________________

Class :______________________

Roll No. :______________________

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Physical Constants[a]

Constant and Symbol[b]		SI Value	Gaussian Value
Speed of light in vaccum	c	2.99×10^8 m/s	2.99×10^{10} cm/s
Proton & electron charge	e	1.60×10^{-19} C	4.8×10^{-10} statC
Permittivity of vaccum	ε_0	8.85×10^{-12} C^2/N-m^2	
Avogadro constant	N_A	6.02×10^{23} mol^{-1}	6.02×10^{23} mol^{-1}
Electron rest mass (0.000548 amu)	m_e	9.10×10^{-31} kg	9.10×10^{-28} g
Proton rest mass (1.00757 amu)	m_P	1.67×10^{-27} kg	1.67×10^{-24} g
Neutron rest mass (1.00893 amu)	m_n	1.67×10^{-27} kg	1.67×10^{-24} g
Planck constant	h	6.62×10^{-34} J s	6.62×10^{-27} erg s
Permeability of vaccums	μ_0	$4\pi \times 10^{-7}$ NC^{-2} s^2	
Bohr radius	a_0	5.29×10^{-11} m	0.529×10^{-8} cm
Bohr's velocity		$2.188 \times 10^6 \times \frac{Z}{n}$ m/sec.	$2.188 \times 10^8 \times \frac{Z}{n}$ cm/sec.
Bohr's energy (–13.6 eV/atom)		$-21.8 \times 10^{-19} \frac{Z^2}{n^2}$ J/atom	-21.8×10^{-12} erg/atom
Bohr magneton (BM)	β_e	9.27×10^{-24} J/T	
Gas constant	R	8.3145 J/mol-K	8.3145×10^7 erg/mol-K
Boltzmann constant	k	1.38×10^{-23} J/K	1.30×10^{-16} erg/K
Gravitional constant	G	6.67×10^{-11} m^3/kg -s^2	6.67×10^{-8} cm^3/g-s^2

Energy Conversion Factors[a]

1 erg = 10^{-7} J
1 cal = 4.184 J
1 eV = 1.602177×10^{-19} J = 1.602177×10^{-12} erg = 23.0605 kcal/mol

Greek Alphabet

Alpha	Α	α	Beta	Β	β
Gamma	Γ	γ	Delta	Δ	δ
Epsilon	Ε	ε	Zeta	Ζ	ζ
Eta	Η	η	Theta	Θ	θ
Iota	Ι	ι	Kappa	Κ	κ
Lambda	Λ	λ	Mu	Μ	μ
Nu	Ν	ν	Xi	Ξ	ξ
Omicron	Ο	ο	Pi	Π	π
Rho	Ρ	ρ	Sigma	Σ	σ
Tau	Τ	τ	Upsilon	Υ	υ
Phi	Φ	φ	Chi	Χ	χ
Psi	Ψ	ψ	Omega	Ω	ω

KEY CONCEPT

STRUCTURE OF ATOM

Rutherford's Model

Bohr's Model

Wave mechanical model

EXTRA NUCLEAR PART (e^-)

Electrons,protons & neutrons are the most important fundamental particles of atoms of all elements (Except hydrogen)

Some uncommon Fundamental particles :

1. $_ZX^A$, A = Z + n

2. Reduced mass $\frac{1}{\mu}=\frac{1}{M}+\frac{1}{m}=\frac{mM}{m+M}$ m = mass of e^- ; M = Mass of nucleus

3. Photon is considered massless bundle of energy. But to find its mass use $m=\frac{h}{\lambda c}$

4. $E = mc^2$, $E = h\nu = hc/\lambda = hc\bar{\nu}$

5. Quantum efficiency or Quantum Yield = $\frac{\text{no. of molecules reacting}}{\text{no. of quanta absorbed}}$

6. $R_n = R_1 (A)^{1/3}$, $R_1 = 1.33 \times 10^{-13}$ cm A = mass number

7. $\frac{1}{2}m_\alpha v_\alpha^2 = K\frac{Z_e \cdot 2e}{r}$ **;** $\tan\frac{\theta}{2}\ \alpha\ \frac{1}{b}$

number of a particles at $\theta = K\frac{1}{\sin^4\theta/2}$; b = impact parameter

8. Rydberg's Equation $\frac{1}{\lambda}=\bar{\nu}=R_H\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right]\times Z^2$

9. Limiting spectral line (series limit) means $n_2 = \infty$

10. H_α line means we know n_1 , n_2 (longest λ , shortest ν , least E) [H_α , H_β , H_γ , H_δ]

11. No. of wavelengths observed in the spectrum = $\frac{n(n-1)}{2}$

when e^- deexcites to ground state , n = no. of higher orbit

12. $1/2\, mv^2 = h\nu - h\nu^0$(w) (work function or B.E.)

ν^0 = Threshhold frequency $W = h\nu_0 = \frac{hc}{\lambda_0}$

13. Accelerating potential = eV = KE = $\frac{1}{2}mv^2$

14. λ = hc/E = 1240 ev. nm

15. $K=\frac{1}{4\pi\varepsilon_0}$; P.E. = $\frac{K q_1 q_2}{r}$ centrifugal force = $\mathbf{mv^2/r}$

16. $mvr = n\cdot\frac{h}{2\pi} = n.\hbar$

17. $E_n = \frac{E_1}{n^2}z^2 = -\frac{2\pi^2 me^4}{n^2h^2}\ z^2$; $E_1 = \frac{-2\pi^2 me^4}{h^2}$

18. $r_n = \frac{n^2}{Z} \times \frac{h^2}{4\pi^2 e^2 m}$

19. $v = \frac{z}{n} \times \frac{2\pi e^2}{h}$

20. revolutions per sec = $v/2\pi r$

21. Time for one revolution = $2\pi r/v$

22. Separation energy = $E_{n_\infty = \infty} - E_{n\ \text{given}\ =\ 2,3,4,\ldots}$

23. No. of waves = n = no. of shells

24. I.E. = $E_{n=\infty} - E_{\text{ground state of e-}}$ (K, L, M, N)

25. $\lambda = h/mv = h/p$

26. $\lambda = \sqrt{\frac{150}{V \text{in volts}}}$ Å

27. $E_n \neq KE$ $KE = 1/2\ mv^2$, $E = h\nu$

28. $\Delta x . \Delta p > h/4\pi$

29. $\nu^{1/2} = a(z-b)$ b = screening constant

30. Nucleons

31. Isotopes, Isobars, Isotones (A – Z)

32. Isoelectronic

33. Isosters

34. Isodiaphers (A – 2Z)

35. paramagnetic

36. Diamagnetic

37. $S = \frac{h}{2\pi}\sqrt{S(S+1)}$

38. $\mu = \sqrt{n(n+2)}$ B.M. n = number of unpaired e^- ;

39. Radial Nodes ; Angular nodes ; Total nodes
    $(n - l - 1)$; l ; $(n-1)$

40. Total no. of e^- in an energy level = $2n^2$
    Total no. of e^- in a sublevel = $2(2l+1)$
    Maximum no. of e^- in an orbital = 2
    Total no. of orbitals in a sublevel = $(2l+1)$
    No. of subshells in main energyshell = n
    No. of orbitals in a main energy shell = n^2

l =	0	1	2	3	4
	s	p	d	f	g

41. **ELEECTROMEGNETIC SPECTRUM**

→ λ increases

Cosmic Rays	γ- rays	X - Rays	Vaccum UV	UV	Visible	Nrar IR	Far IR	Micro Waves	Radio Waves

$\lambda =$ 10^{-14} 10^{-13} 10^{-12} 10^{-11} 10^{-10} 10^{-9} 10^{-8} 10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 10^{0}

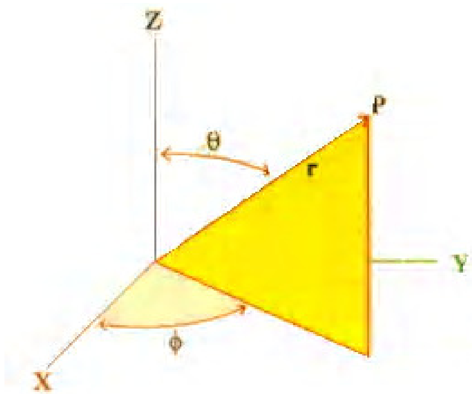
λ in meters.

Distinction between the wave – particle nature of a photon and the particle–wave nature of sub-atomic particle.

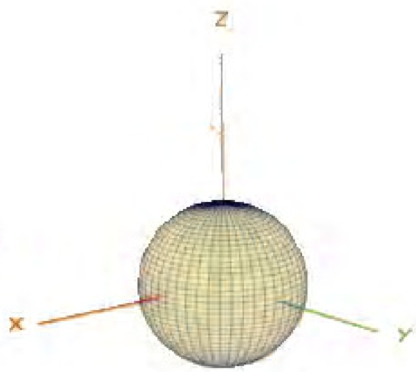
	PHOTON	**SUB ATOMIC PARTICLE**
1.	Energy = $h\nu$	Energy = $\frac{1}{2} mv^2$
2.	Wavelength = $\frac{c}{\nu}$	Wavelength = $\frac{h}{mv}$

***Note**: We should never interchange any of the above and to write electronic conf. of Cation first write for neutral atom & then remove e^- from outermost shell.*

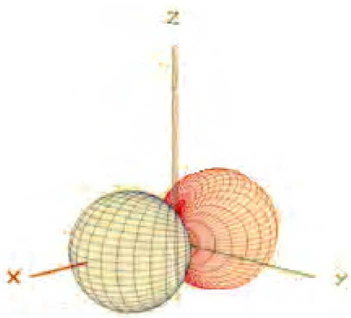
SHAPES OF ATOMIC ORBITALS



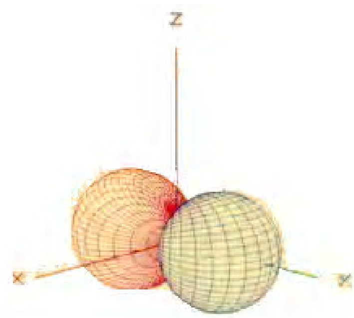
The spherical Polar Coordinates



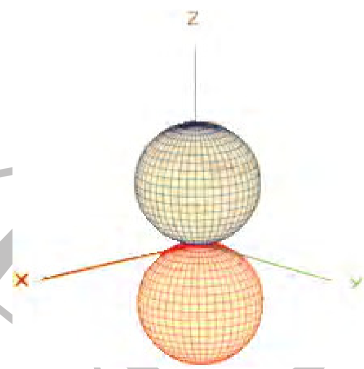
S



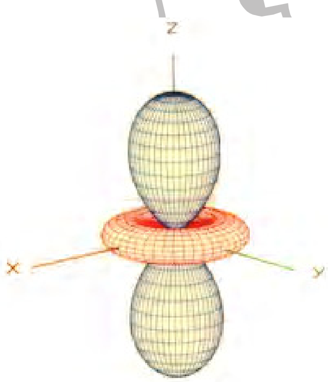
p_X



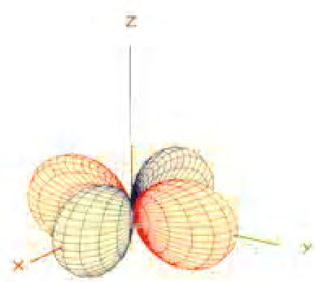
p_y



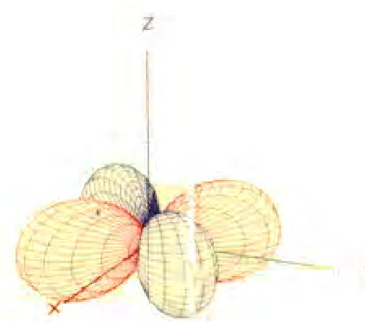
p_z



d_{z^2}



$d_{x^2-y^2}$



d_{xy}

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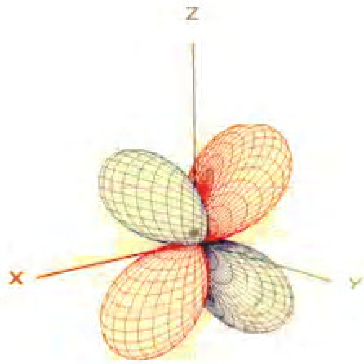
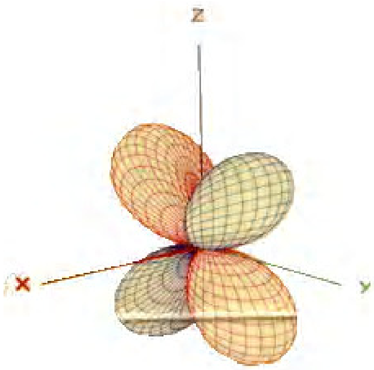
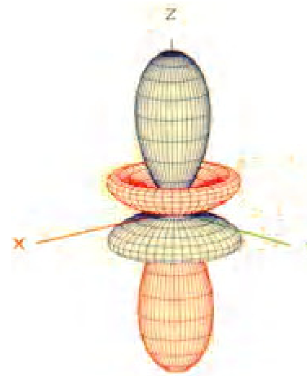


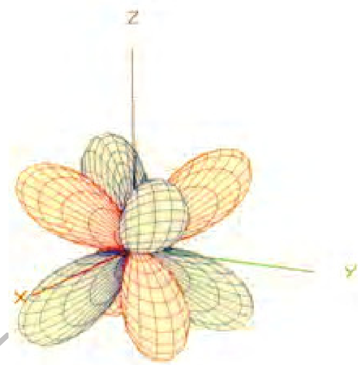
d_{xz}



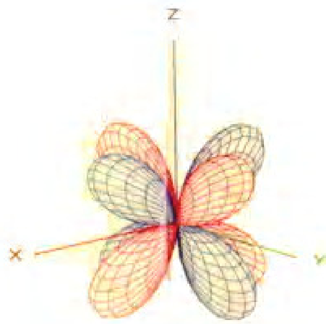
d_{yz}



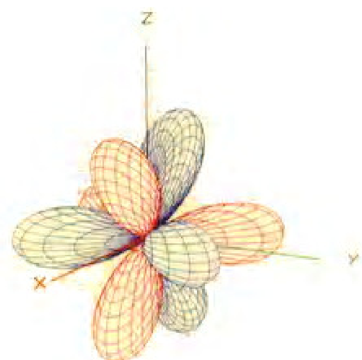
f_{z^3}



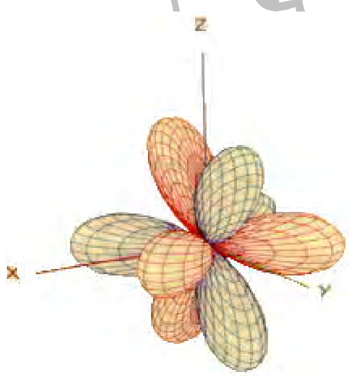
f_{xyz}



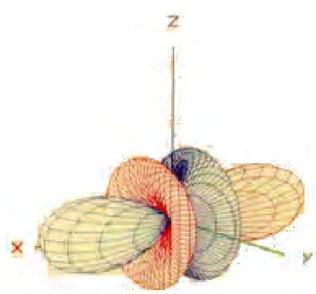
$f_{z(x^2-y^2)}$



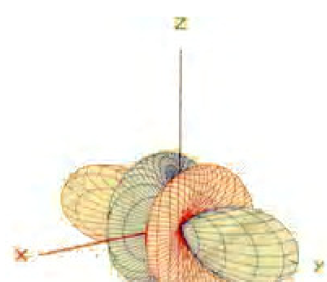
$f_{x(y^2-z^2)}$



$f_{y(z^2-x^2)}$



f_{x^3}



f_{y^3}

EXERCISE -I

LIGHT

Q.1 H- atom is exposed to electromagnetic radiation of 1028 Å and gives out induced radiations. Calculate λ of induced radiations.

Q.2 The wavelength of a certain line in the Paschen series in 1093.6 nm. What is the value of n_{high} for this line. $[R_H = 1.0973 \times 10^{+7}\ m^{-1}]$

Q.3 A certain dye absorbs 4530 Å and fluoresces at 5080 Å 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.

Q.4 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.

Q.5 Wavelength of the Balmer H_α line (first line) is 6565 Å. Calculate the wavelength of H_β (second line).

Q.6 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 133.7nm.

Q.7 The quantum yield for decomposition of HI is 2. In an experiment 0.01 moles of HI are decomposed. Find the number of photons absorbed.

Q.8 The light radiations with discrete quantities of energy are called ______.

Q.9 What transition in the hydrogen spectrum would have the same wavelength as the Balmer transition, n=4 to n=2 of He^+ spectrum.

Q.10 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.

PLANCK'S QUANTUM THEORY

Q.11 Calculate the wavelength of the radiation that would cause photo dissociation of chlorine molecule if the Cl- Cl bond energy is 243 KJ/mol.

Q.12 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 ($\lambda = 550$ nm) are needed to generate this minimum amount of energy.

Q.13 A photon having $\lambda = 854$ Å causes the ionization of a nitrogen atom. Give the I.E. per mole of nitrogen in KJ.

Q.14 Calculate the threshold frequency of metal if the binding energy is 180.69 KJ mol^{-1} of electron.

Q.15 Calculate the binding energy per mole when threshold wavelength of photon is 240 nm.

Q.16 A metal was irriadated by light of frequency $3.2 \times 10^{15}\ S^{-1}$. The photoelectron produced had its KE, 2 times the KE of the photoelectron which was produced when the same metal was irriadated with a light of frequency $2.0 \times 10^{15}\ S^{-1}$. What is work function.

Q.17 U.V. light of wavelength 800 Å & 700 Å falls on hydrogen atoms in their ground state & liberates electrons with kinetic energy 1.8 eV and 4 eV respectively. Calculate planck's constant.

Q.18 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.

Q.19 A potential difference of 20 KV is applied across an X-ray tube. Find the minimum wavelength of X-ray generated.

Q.20 The K.E. of an electron emitted from tungstan surface is 3.06 eV. What voltage would be required to bring the electron to rest.

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BOHR'S MODEL

Q.21 Calculate energy of electron which is moving in the orbit that has its rad. sixteen times the rad. of first Bohr orbit for H–atom.

Q.22 The electron energy in hydrogen atom is given by $E_n = \frac{-21.7\times10^{-12}}{n^2}$ 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.

Q.23 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.

Q.24 The radius of the fourth orbit of hydrogen atom is 0.85 nm. Calculate the velocity of electron in this orbit.

Q.25 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 from the quatum state (n+1) to the ground state.

Q.26 Electrons of energy 12.09 eV can excite hydrogen atoms. To which orbit is the electron in the hydrogen atom raised and what are the wavelengths of the radiations emitted as it drops back to the ground state.

Q.27 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.

Q.28 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.

Q.29 Find out the no. of waves made by a Bohr electron in one complete revolution in its 3rd orbit.

Q.30 Iodine molecule dissociates into atoms after absorbing light of $4500A^0$. 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)

Q.31 Calculate the wavelength of radiation emitted, producing a line in Lyman series, when an electron falls from fourth stationary state in hydrogen atom.

Q.32 Calculate the wave no. for the shortest wavelength transition in the Balmer series of atomic hydrogen.

GENERAL

Q.33 What is de-Broglie wavelength of a He-atom in a container at room temperature.(Use U_{avg})

Q.34 Through what potential difference must an electron pass to have a wavelength of 500 Å.

Q.35 A proton is accelerated to one- tenth of the velocity of light. If its velocity can be measured with a precision $\pm$ 1%. What must be its uncertainity in position.

Q.36 To what effective potential a proton beam be subjected to give its protons a wavelength of 1×10^{-10} m.

Q.37 Calculate magnitude of angular momentum of an e^- that occupies 1s, 2s , 2p , 3d , 3p.

Q.38 Calculate the number of exchange pairs of electrons present in configuration of Cu according to Aufbau Principle considering 3d & 4s orbitals.

Q.39 He atom can be excited to $1s^1\,2p^1$ by λ = 58.44 nm. If lowest excited state for He lies 4857cm^{-1} below the above. Calculate the energy for the lower excitation state.

Q.40 Wave functions of electrons in atoms & molecules are called________.

Q.41 The outermost electronic conf. of Cr is___________.

EXERCISE-II

Q.1 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 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.

Q.2 1.8 g hydrogen atoms 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.

Q.3 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.

Q.4 The energy of an excited H-atom is –3.4 eV. Calculate angular momentum of e^-.

Q.5 The vapours of Hg absorb some electrons accelerated by a potential diff. of 4.5 volt as a result of which 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.

Q.6 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.

Q.7 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 3.15×10^{-14} J is required to trip the signal, what is the minimum number of photons that must strike the receptor.

Q.8 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.

Q.9 Calculate the frequency of e^- in the first Bohr orbit in a H-atom.

Q.10 A single electron orbits around a stationary nucleus o f 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 and give the hydrogen like species formed.

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

Q.11 A stationary He^+ ion emitted a photon corresponding to a first line of the Lyman series. The photon liberated a photon electron from a stationary H atom in ground state. What is the velocity of photoelectron.

Q.12 To what series does the spectral lines of atomic hydrogen belong if its wave 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.

Q.13 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 nth 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 th ehydrogen atom, and (c) find the wavelength of the radiation emitted when the revolving particle jumps from the third orbit to the first.

Q.14 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 electromagentic 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 Aluminium atom. IE_1 = of Al = 577 KJ/mol

Q.15 Find the number of photons of radiation of frequency $5 \times 10^{13}\ s^{-1}$ that must be absorbed in order to melt one gm ice when the latent heat of fusion of ice is 330 J/g.

Q.16 The dye acriflavine, when dissolved in water, has its maximum light absorption at 4530 Å and its maximum fluorescence emission at 5080 Å. The number of fluorescence quanta is, on the average, 53% of the number of quanta absorbed. Using the wavelengths of maximum absorption and emission, what % of absorbed energy is emitted as fluorescence?

Q.17 Hydrogen atom in its ground state is excited by means of monochromatic radiation of wavelength 975Å. How many different lines are possible in the resulting spectrum? Calculate the longest wavelength amongst them.

Q.18 An alpha particle after passing through a potential difference of 2×10^6 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 5×10^{-14}m from the nucleus, (iii) the shortest distance from the nucleus of silver to which the α–particle reaches.

Q.19 Suppose the potential energy between electron and proton at a distance r is given by $-\dfrac{ke^2}{3r^3}$. Use Bohr's theory to obtain energy of such a hypothetical atom.

Q.20 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.

Q.21 A proton captures a free electron whose K.E. is zero & forms a hydrogen atom of lowest energy-level (n = 1). If a photon is emitted in this process, what will be the wavelength of radiation? In which region of electromagnetic spectrum, will this radiation fall? (Ionisation potential of hydrogen = 13.6 volt, h = 6.6×10^{-34}K/s, C = 3.0×10^8 m/s)

Q.22 The ionisation energy of the hydrogen atom is given to be 13.6 eV. A photon falls on a hydrogen atom which is initially in the ground state and excites it to the (n = 4)state.
(a) show this transition in the energy-level diagram &
(b) calculate the wavelength of the photon.

Q.23 Calculate Total spin and the multiplicity for each possible configuration of N-atom.

(A) [↑↓] [↑↓] [↑↓|↑|] (B) [↑↓] [↑↓] [↑|↓|↑]
(C) [↑↓] [↑↓] [↑| |↑↓] (D) [↑↓] [↑↓] [↑|↑|↑]

Q.24 Find the wavelength of the first line of He^+ ion spectral series whose interval between extreme line is

$$\left[\frac{1}{\lambda_1}-\frac{1}{\lambda_2}=2.7451\times10^4\ \text{cm}^{-1}\right]$$

Q.25 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 = 2.18×10^{-18} J]

DE-BROGLIE

Q.26 What is de Broglie wavelength associated with an e^- accelerated through P.D. = 100 KV.

Q.27 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.

HEISENBERG

Q.28 A base ball of mass 200 g is moving with velocity 30×10^2 cm/s. If we can locate the base ball with an error equal in magnitude to the λ of the light used (5000 Å), how will the uncertainty in momentum be compared with the total momentum of base ball.

Q.29 An electron has a speed of 40 m/s, accurate up to 99.99%. What is the uncertainity in locating its position.

EXERCISE-III

Q.1 The ratio of the energy of a photon of 2000 Å wavelength radiation to that of 4000 Å radiation is
(A) 1 / 4 (B) 4 (C) 1 / 2 (D) 2

Q.2 The maximum energy is present in any electron at
(A) Nucleus (B) Ground state
(C) First excited state (D) Infinite distance from the nucleus

Q.3 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

Q.4 The third line in Balmer series corresponds to an electronic transition between which Bohr's orbits in hydrogen
(A) $5 \rightarrow 3$ (B) $5 \rightarrow 2$ (C) $4 \rightarrow 3$ (D) $4 \rightarrow 2$

Q.5 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) $6, 0, 0, +\frac{1}{2}$

Q.6 The correct set of quantum numbers for the unpaired electron of chlorine atom is

	n	*l*	m		n	*l*	m
(A)	2	1	0	(B)	2	1	1
(C)	3	1	1	(D)	3	0	0

Q.7 The orbital diagram in which the Aufbau's principle is violated is

	2s	$2p_x$	$2p_y$	$2p_z$		2s	$2p_x$	$2p_y$	$2p_z$
(A)	↑↓	↑↓	↑		(B)	↑	↑↓	↑	↑
(C)	↑↓	↑	↑	↑	(D)	↑↓	↑↓	↑↓	↑

Q.8 The total number of neutrons in dipositive zinc ions with mass number 70 is
(A) 34 (B) 40 (C) 36 (D) 38

Q.9 Principal quantum number of an atom represents
(A) Size of the orbital (B) Spin angular momentum
(C) Orbital angular momentum (D) Space orientation of the orbital

Q.10 Which of the following sets of quantum numbers represent an impossible arrangement

	n	*l*	m	m_s		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	$\frac{1}{2}$

Q.11 The orbital angular momentum of an electron in 2s orbital is:
(A) $+\frac{1}{2}.\frac{\hbar}{2\pi}$ (B) Zero (C) $\frac{\hbar}{2\pi}$ (D) $\sqrt{2}.\frac{\hbar}{2\pi}$

Q.12 The explanation for the presence of three unpaired electrons in the nitrogen atom can be given by
(A) Pauli's exclusion principle (B) Hund's rule
(C) Aufbau's principle (D) Uncertainty principle

Q.13 The maximum number of electrons that can be accommodated in the M^{th} shell is
(A) 2 (B) 8 (C) 18 (D) 32

Q.14 Which quantum number will determine the shape of the subshell
(A) Principal quantum number (B) Azimuthal quantum number
(C) Magnetic quantum number (D) Spin quantum number

Q.15 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

Q.16 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)

Q.17 Which quantum number is not related with Schrodinger equation
(A) Principal (B) Azimuthal (C) Magnetic (D) Spin

Q.18 According to Bohr's atomic theory, which of the following is/are correct:

(I) Kinetic energy of electron $\propto \frac{Z^2}{n^2}$

(II) The product of velocity of electron and principle quantum number 'n' $\propto Z^2$

(III) Frequency of revolution of electron in an orbit $\propto \frac{Z^2}{n^3}$

(IV) Coulombic force of attraction on the electron $\propto \frac{Z^3}{n^4}$

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

Q.19 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) $\left[\frac{h\lambda\lambda_0}{2mc}\right]^{\frac{1}{2}}$

Q.20 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

Q.21 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 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

Q.22 Predict the magnetic moment for S^{2-}, Co^{3+} [At. no. of S = 16, Co = 27]

Q.23 The critical wavelength for producing the photoelectric effect in tungsten is 2600Å. What wavelength would be necessary to produce photoelectrons from tungston having twice the kinetic energy of these produced at 2200Å ?

Q.24 The shortest wavelength of He atom 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) $\frac{5x}{9}$

Q.25 An electron in a hydrogen atom in its ground state absorbs energy equal to the 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

Q.26 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

Q.27 An electron, a proton and an alpha particle have kinetic energies of 16E, 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) $\lambda_\alpha < \lambda_e \gg \lambda_p$

Q.28 **Question**: Is the specie paramagnetic?

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

STAT-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.

Q.29 **Question :** Are the rays in discharge tube cathode rays?

STAT1 : Rays are deflected towards – ve electrode kept externally.

STAT2 : Rays are produced at low pressure and high voltage.

(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) Any one of them is sufficient.

Q.30 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

Q.31 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

Q.32 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 us 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.

Q.33 The quantum numbers of four electrons (e1 to e4) are given below

	n	l	m	s		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

Q.34 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) 2.25R

Q.35 An electron in a hydrogen atom in its ground state absorbs 1.5 times as much energy as the minimum required for it to escape from the atom. What is the velocity of the emitted electron?
(Given mass of $e^- = 9.1 \times 10^{-28}$ gm)

PROBLEM ON DE-BROGLIE, HEISENBERG & SCHRODINGER EQUATIONS

Q.36 An electron can undergo diffraction by crystals . Through what potential should a beam of electron be accelerated so that its wavelength become equal to 1.54 A° .

Q.37 The first use of quantum theory to explain the structure of atom was made by :
(A) Heisenburg (B) Bohr (C) Planck (D) Einstein

Q.38 The wavelength associated with a golf weighing 200g and moving at a speed of 5m/h is of the order
(A) 10^{-10}m (B) 10^{-20}m (C) 10^{-30}m (D) 10^{-40}m

Q.39 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 uncertainity principle (B) Hunds rule
(C) Pauli's exclusion principle (D) Bohr postulate of stationary orbits

Q.40 Wavelength of high energy transition of H-atoms is 91.2 nm. Calculate the corresponding wavelength of He atoms.

Q.41(i) The wave function of 2s electron is given by

$$\Psi 2s = \frac{1}{4\sqrt{2\pi}}\left(\frac{1}{a_o}\right)^{3/2}\left(2-\frac{r}{a_o}\right)e^{\left(2-\frac{r}{a_o}\right)}$$

It has a node at $r = r_0$, find relation between r_0 and a_0.

(ii) Find wavelength for 100 g particle moving with velocity 100 ms^{-1}.

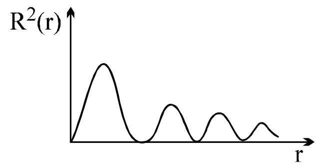
Q.42 The electron in the first excited state of H-atom absorbs a proton and is further excited. the Debroglie wavelength of the electron in this excited state is 1340 pm. Calculate the wavelength of photon absorbed by the atom and also longest wavelength radiation emitted when this electron de-excited to ground state.

Q.43 The uncertainity principle may be stated mathematically

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

where Δp represents the uncertainity in the momentum of a particle and Δx represnts the uncertainity in its position. If an electron is traveling at 200 m/s within 1 m/s uncertainity, what is the theoretical uncertainity in its position in μm (micrometer)?

Q.44 From the following observations predict the type of orbital:
Observation 1: x y plane acts as a 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) $6\ d_{x^2-y^2}$ (D) $6\ d_{yz}$

Q.45 **Question :** Is the orbital of hydrogen atom $3p_x$?

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

STAT 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

Q.46 What is uncertainity in location of a photon of wavelength 5000Å if wavelength is known to an accuracy of 1 pm?
(A) 7.96×10^{-14} m (B) 0.02 m (C) 3.9×10^{-8} m (D) none

EXERCISE-IV

Q.1 With what velocity should an α–particle travel towards the nucleus of a Cu atom so as to arrive at a distance 10^{-13} m. **[JEE 1997]**

Q.2 A compound of Vanadium has magnetic moment of 1.73 BM work out electronic configuration of Vanadium Ion in the compound. **[JEE 1997]**

Q.3 The energy of an electron in the first Bohr orbit of H atom is -13.6 eV. The possible energy value(s) of the excited state(s) for electrons in Bohr orbits of hydrogen is/are :
(A) -3.4 eV (B) -4.2 eV (C) -6.8 eV (D) $+6.8$ eV **[JEE 1998]**

Q.4 The electrons, identified by n & l ; (i) n = 4 , l = 1 (ii) n = 4 , l = 0
(iii) n = 3 , l = 2 (iv) n = 3 , l = 1 can be placed in order of increasing energy, from the lowest to highest as :
(A) (iv) < (ii) < (iii) < (i) (B) (ii) < (iv) < (i)
(C) (i) < (iii) < (ii) < (iv) (D) (iii) < (i) < (iv) < (ii) **[JEE 1999]**

Q.5 Gaseous state electronic configuration of nitrogen atom can be represented as:

(A) ↑↓ ↑↓ ↑ ↑ ↑ (B) ↑↓ ↑↓ ↑ ↓ ↑

(C) ↑↓ ↑↓ ↑ ↓ ↓ (D) ↑↓ ↑↓ ↓ ↓ ↓ **[JEE 1999]**

Q.6 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 **[JEE 2000]**

Q.7 The number of nodal planes in a p_x orbital is:
(A) one (B) two (C) three (D) zero **[JEE 2000]**

Q.8 Calculate the energy required to excite one litre of hydrogen gas at 1 atmp and 298K to the first excited state of atomic hydrogen. The energy for the dissociation of H – H is 436 KJ mol^{-1}.

Q.9 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 classical analogue. **[JEE 2001]**

Q.10 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.
(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. **[JEE 2002]**

Q.11 The spin magnetic moment of cobalt of the compund $Hg[Co(SCN)_4]$ is [Given : Co^{+2}]
(A) $\sqrt{3}$ (B) $\sqrt{8}$ (C) $\sqrt{15}$ (D) $\sqrt{24}$ **[JEE 2004]**

Q.12 The radius of which of the following orbit is same as that of the first Bohr's orbit of hydrogen atom?
(A) He^+ (n = 2) (B) Li^{2+} (n = 2) (C) Li^{2+} (n = 3) (D) Be^{3+} (n = 2)
[JEE 2004]

Q.13 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 = (Angular momentum of electron in its lowest energy)	(S)	0

ANSWER KEY

EXERCISE -I

LIGHT

Q.1 6563 Å ; 1216 Å ; 1026 Å Q.2 6 Q.3 0.527
Q.4 6235 Å Q.5 4863 Å Q.6 $1.096 \times 10^{7}\ m^{-1}$
Q.7 3×10^{21} Q.8 photons Q.9 $n_1 = 1, n_2 = 2$ Q.10 1.827×10^{5} J/mol

PLANCK'S QUANTUM THEORY

Q.11 4.9×10^{-7} m Q.12 28 photons Q.13 1403 KJ/mol Q.14 $4.5 \times 10^{14}\ s^{-1}$
Q.15 497 KJ/mol Q.16 319.2 KJ/mol Q.17 6.57×10^{-34} Js
Q.18 8.68 % Q.19 0.62 Å Q.20 3.06 V

BOHR'S MODEL

Q.21 -1.36×10^{-19} Joules Q.22 5.425×10^{-12} ergs, 3.7×10^{-5} cm
Q.23 1220 Å Q.24 5.44×10^{5} m/s Q.25 2 ; $9.75 \times 10^{4}\ cm^{-1}$
Q.26 3 , 6563 Å , 1215 Å , 1026 Å Q.27 113.74 Å
Q.28 10.2 eV , z = 2 Q.29 3 Q.30 2.186×10^{-20} Joules
Q.31 9.7×10^{-8} m Q.32 27419.25 cm^{-1}

GENERAL

Q.33 0.79 Å Q.34 6.03×10^{-4} volt Q.35 1.05×10^{-13} m
Q.36 0.0826 volts Q.37 0 ; 0 ; $\sqrt{2}\frac{h}{2\pi}$; $\sqrt{6}\frac{h}{2\pi}$; $\sqrt{2}\frac{h}{2\pi}$ Q.38 25
Q.39 3.3×10^{-18} J Q.40 orbitals Q.41 $3s^2\ 3p^6\ 3d^5\ 4s^1$

EXERCISE-II

Q.1 24
Q.2 292.68×10^{21} atoms, 162.60×10^{21} atoms, 832.50 KJ Q.3 331.13×10^{4} J
Q.4 h/π Q.5 $3.63 \times 10^{6}\ m^{-1}$ Q.6 938 Å Q.7 1.35×10^{5}
Q.8 8×10^{6} Q.9 6530×10^{12}Hz Q.10 5 ; 340 ev , – 680 eV
Q.11 3.09×10^{8} cm/sec Q.12 Brackett ; 2.63×10^{-4} cm
Q.13 $r_n = \frac{n^2 h^2}{4K\pi^2 \times 3e^2 \times 208\, m_e}$ n = 25 ; 55.2 pm Q.14 9.15×10^{19} Hz , yes, 58.5×10^{-15} J
Q.15 10^{22} Q.16 47.26% Q.17 six , 18800 Å
Q.18 6.4×10^{-13} J, 2.1×10^{-13}J, 3.4×10^{-14}m Q.19 $E = \frac{n^6 h^6}{384\, m^3\, K^2\, e^4\, \pi^6}$
Q.20 6 ; 489.6 eV , 25.28 Å Q.21 910 Å ;U.V. Q.22 973.5 Å
Q.23 +1/2 , +1/2 , +1/2 , +3/2 and 2,2,2,4 Q.24 4689 Å
Q.25 303.89 Å , 2.645×10^{-9} cm

DE-BROGLIE

Q.26 3.88 pm Q.27 3.68×10^{-65} m

HEISENBERG

Q.28 1.75×10^{-29} Q.29 0.0144 m

EXERCISE-III

Q.1	D	Q.2	D	Q.3	D	Q.4	B	Q.5	A	Q.6	C	Q.7	B
Q.8	B	Q.9	A	Q.10	C	Q.11	B	Q.12	B	Q.13	C	Q.14	B
Q.15	B	Q.16	C	Q.17	D	Q.18	A	Q.19	A	Q.20	C	Q.21	C
Q.22	zero, 4.9 B.M.			Q.23	$\lambda = 1900$Å			Q.24	B	Q.25	B	Q.26	B
Q.27	A	Q.28	C	Q.29	A	Q.30	A	Q.31	B	Q.32	C	Q.33	C
Q.34	D	Q.35	1.54×10^6 m/s										

PROBLEM ON DE-BROGLIE, HEISENBERG & SCHRODINGER EQUATIONS

Q.36 63.12 volts; Q.37 B; Q.38 C; Q.39 C

Q.40 22.8 nm; Q.41 (i) $r_0 = 2a_0$, (ii) 6.626×10^{-35} m; Q.42 4860 Å, 18788 Å

Q.43 $\approx 2.9 \times 2 \times 10^{-5}$ m $\approx$ 58 μm; Q.44 D; Q.45 B; Q.46 B

EXERCISE-IV

Q.1	6.3×10^6 m/s	Q.2	[Ar] $3d^1$	Q.3	A	Q.4	A
Q.5	A,D	Q.6	B,C	Q.7	A	Q.8	97.819 KJ
Q.9	D	Q.10	D	Q.11	C	Q.12	D

Q.13 (A) Q, (B) P, (C) R, (D) S