

Revision Worksheet Atomic Structure & General chemistry**Single correct**

- Q.1 The kinetic energy of an electron in the second Bohr orbit of a hydrogen atom is [a_0 is Bohr radius]
- (A) $\frac{h^2}{4\pi^2 ma_0^2}$ (B) $\frac{h^2}{16\pi^2 ma_0^2}$ (C*) $\frac{h^2}{32\pi^2 ma_0^2}$ (D) $\frac{h^2}{64\pi^2 ma_0^2}$
- Q.2 In a hydrogen atom, in transition of electron a photon of energy 2.55 eV is emitted, then the change in wavelength of the electron is
- (A) 3.32 Å (B*) 6.64 Å (C) 9.97 Å (D) None of these
- Q.3 A charged particle having specific charge 4×10^{10} col/kg is projected towards nucleus of Zn atom. What is the distance of closest approach if initial speed of projection is 3×10^6 m/s?
- (A) 38.4 pm (B) 3.84 nm (C*) 3.84 Å (D) 3.84×10^{-11} nm
- Q.4 In a sample of hydrogen atoms, electrons jump from 10^{th} excited state to ground state. If x are the number of different ultraviolet radiations, y are number of different visible radiations and z are number of different infrared radiations. The value of $z - (x + y)$ is.
[Assume all the Balmer lines lie within visible region]
- (A*) 17 (B) 18 (C) 19 (D) 36
- Q.5 If spin quantum number has 4 values instead of two then identify the incorrect statement.
- (A) First period will be shortest with 4 elements
(B) Fourth period can have maximum 36 elements
(C) Each orbital can have maximum 4 electrons.
(D*) For a given value of "n" (principal quantum number) number of electrons will be $2n^2$.
- Q.6 The time period of revolution in the 3^{rd} orbit of Li^{2+} ion is x sec. The time period of revolution in the 2^{nd} orbit of He^+ ion, should be
- (A) x sec (B) $\frac{3}{2}$ x sec (C*) $\frac{2}{3}$ x sec (D) $\frac{8}{27}$ x sec
- Q.7 In the hydrogen spectrum, the **longest wavelength** in the Lyman series is $x\text{Å}$ and the **shortest wavelength** in the Balmer series is $y\text{Å}$. Hence, the **longest wavelength** of light needed to ionise a hydrogen atom from its ground state should be
- (A) $(x + y)\text{Å}$ (B) $(y - x)\text{Å}$ (C*) $\frac{xy}{(x + y)}\text{Å}$ (D) $\frac{(x + y)}{xy}\text{Å}$
- Q.8 The orbital angular momentum of an electron is $\sqrt{3}\frac{h}{\pi}$. Which of the following may be the permissible value of angular momentum of this electron revolving in unknown Bohr orbit?
- (A) $\frac{h}{2\pi}$ (B) $\frac{h}{\pi}$ (C) $3\frac{h}{2\pi}$ (D*) $2\frac{h}{\pi}$
- Q.9 A photon of wavelength 12.4 nm is used to emit an electron from the ground state of He^+ . Calculate the debroglie wavelength of emitted electron
- (A) 1.2 Å (B) 2.2 Å (C*) 1.8 Å (D) 2.7 Å
- Q.10 When electron jumps from 4^{th} orbit to 2^{nd} orbit in He^+ ion, the radiation emitting out will fall in
- (A*) ultraviolet region (B) visible region (C) infrared region (D) radiowave region

- Q.18 Choose the correct statement among the following
- (A) Radial distribution function ($\Psi^2 \cdot 4\pi r^2 dr$) give probability at a particular distance along one chosen direction
- (B) $\Psi^2(r)$ give probability density at a particular distance over a spherical surface
- (C*) For 's' orbitals $\Psi(r)\Psi(\theta)\Psi(\phi) = \Psi(x, y, z)$ is independent of θ and ϕ
- (D*) '2p' orbital with quantum numbers. $n = 2, \ell = 1, m = 0$, also shows angular dependence
- Q.19 Which of the following statements regarding Bohr's Model of an atom are **incorrect**?
- (A) Energy difference between successive energy levels will keep on decreasing as principal quantum number increases.
- (B*) Distance between Bohr's orbit will keep on decreasing as principal quantum number increases.
- (C*) Ionisation energy of Li^{+1} is equal to 9 Rydbergs.
- (D*) A photon of energy 30eV can cause excitation in He^+ ion present in ground state.

Assertion Reason

- Q.20 **Statement-1:** Energy emitted when an electron jump from $5 \rightarrow 2$ (energy level) is less than when an electron jump from $2 \rightarrow 1$ in all 'H' like atom.
- Statement-2:** The |total energy difference| between 1st & 2nd energy level is greater than that of any two energy level provided level '1' is not part of those two energy levels.
- (A*) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
- (B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
- (C) Statement-1 is true, statement-2 is false.
- (D) Statement-1 is false, statement-2 is true.

Comprehension :**Paragraph for question nos. 21 to 23**

An unknown orbital is having the following equation for its wavefunction.

$$\psi(r, \theta, \phi) = \frac{2}{3} \left(\frac{Z}{3a_0} \right)^{3/2} (\sigma - 1)(\sigma^2 - 8\sigma + 12)\sigma e^{-\sigma/2} \cos \theta$$

where $\sigma = \frac{2Zr}{a_0}$, a_0 is constant = 0.529 Å and all other parameters have usual meaning. Based on this data answer the question that follow.

- Q.21 What is the number of total nodes of the orbital? (Total nodes = radial nodes + angular nodes)
- (A) 3 (B*) 4 (C) 2 (D) 5
- Q.22 If ' θ ' is the angle measured from z-axis, then the above wavefunction represents which orbital.
- (A) s-orbital (B) d_{xy} orbital (C*) p_z orbital (D) d_{z^2} orbital
- Q.23 The maximum distance from the nucleus, where there will a radial node will be given by :
- (A) $r = \frac{a_0}{Z}$ (B*) $r = \frac{3a_0}{Z}$ (C) $r = \frac{6a_0}{Z}$ (D) $r = \frac{2a_0}{Z}$

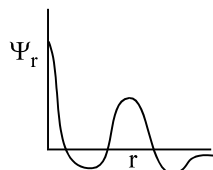

Match the column :

Q.24 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.

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

[Ans. (A) Q,R (B) P, Q, R,S (C) P, Q, R (D) P, Q]

Q.25 Column I & column II contain data on Schrodinger Wave-Mechanical model, where symbols have their usual meanings. Match the columns.

Column I		Column II (Type of orbital)	
(A)		(P)	4s
(B)		(Q)	any 5p orbital
(C)	$\Psi(\theta, \phi) = K$ (independent of θ & ϕ)	(R)	3s
(D)	at least one angular node is present	(S)	$6d_{xy}$

[Ans. (A) P, (B) P,Q,S, (C) P, R (D) Q, S]

Subjective :

Q.26 Find the product of multiplication of number of electrons corresponding to $(n + l) = 3$ and $l = 2$ in Cu (29). [Ans. 80]

Q.27 Electrons in a sample of H-atoms make transitions from state $n = X$ to some lower excited state. The emission spectrum from the sample is found to contain only the lines belonging to a particular series. If one of the photons had an energy of 0.6375 eV, then find out value of X.

[Take $0.6375 \text{ eV} = \frac{3}{4} \times 0.85 \text{ eV}$] [Ans. 8]

Q.28 A sample of hydrogen atoms in ground state absorbs light of $x \text{ nm}$. If the excited sample emits the radiations of six different photon energies but the detector of these emitted radiations has not detected

ultraviolet radiations, then the value of 'x' is (Given : $R_H = \frac{1}{96} \times 10^9 \text{ m}^{-1}$) [Ans. 0100]

Q.29 Two bulbs A and B are emitting monochromatic light of wavelength such that A can just ionise H atoms & B can just ionise He^+ ions. If the power of A & B are 30 W & 40 W respectively. Calculate the ratio of number of photons emitted per second by bulb A to bulb B? [Ans.0003]

- Q.30 Mr. Santa has to decode a number "ABCDEF" where each alphabet is represented by a single digit. Suppose an orbital whose radial wave function is represented as

$$\Psi_{(r)} = k_1 \cdot e^{-r/k_2} (r^2 - 5k_3r + 6k_3^2)$$

From the following information given about each alphabet then write down the answers in the form of "ABCDEF", for above orbital.

Info A = Value of n where "n" is principal quantum number

Info B = No. of angular nodes

Info C = Azimuthal quantum number of subshell to orbital belongs

Info D = No. of subshells having energy between $(n + 5)s$ to $(n + 5)p$ where n is principal quantum number

Info E = Orbital angular momentum of given orbital.

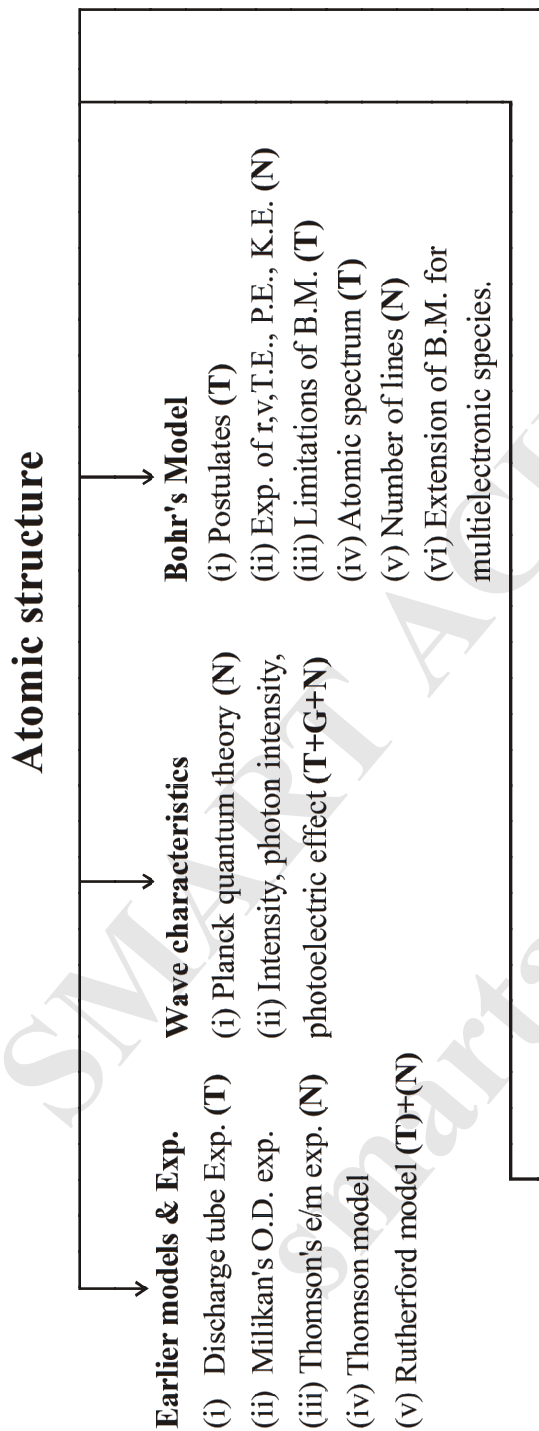
Info F = Radial distance of the spherical node which is farthest from the nucleus

(Assuming $k_3 = 1$)

[Ans.300303]

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Wave Mechanical Model

- (i) DeBroglie & Heisenberg (T + N)
- (ii) Theoretical concepts/assumptions (T)
- (iii) Ψ , Ψ^2 & $\Psi^2 dV$ (N)
- (iv) Radial prob. curves, radial nodes (T)+(G)
- (v) Angular prob. curves (T)+(G)

Quantum numbers &

Electronic configuration

- (i) Significance of each quantum number (T)
- (ii) Expression of orbit angular momentum, orbital angular momentum, spin only (N) magnetic moment, spin multiplicity, magnetic moment & total spin.
- (iii) Rules of electronic configuration & exceptions. (T)
- (iv) Energy of orbitals - Hydrogen & multi electronic. (T)

(G) → represents topic of graphical importance

(T) → represents topic of theoretical importance

(N) → represents topic of numerical importance

LIST OF IMPORTANT FORMULAS

<u>Constants</u>	Symbol	SI Value	
Electron rest mass	m_e	9.10×10^{-31} kg	0.000548 amu
Proton rest mass	m_p	1.67×10^{-27} kg	1.00757 amu
Neutron rest mass	m_n	1.67×10^{-27} kg	1.00893 amu
Planck constant	h	6.62×10^{-34} J s	6.62×10^{-27} erg s
Bohr magneton (BM)	β_e	9.27×10^{-24} J/T	
Gas constant	R	8.3145 J/mol-K	0.0821 atm-lit / mol / K

Energy Conversion Factors

$$1 \text{ erg} = 10^{-7} \text{ J}$$

$$1 \text{ cal} = 4.184 \text{ J}$$

$$1 \text{ eV} = 1.602177 \times 10^{-19} \text{ J} = 1.602177 \times 10^{-12} \text{ erg} = 23.0605 \text{ kcal/mol}$$

STRUCTURE OF ATOM**1. Rutherford's Model**

$$(a) R_n = R_1 (A)^{1/3}, \quad R_1 = 1.33 \times 10^{-13} \text{ cm} \quad A = \text{mass number} \quad R_n = \text{Radius of nucleus}$$

$$(b) \frac{1}{2} m_\alpha v_\alpha^2 = K \frac{Z \cdot 2e}{r}; \quad r = \text{distance of closest approach}, \quad v_\alpha = \text{initial velocity of a } \alpha\text{-particle}$$

2. Light

(a) Photon is considered massless bundle of energy.

$$(b) E = mc^2$$

$$(c) E_{\text{photon}} = h\nu = hc/\lambda = hc \bar{\nu}$$

$$(d) E = \frac{hc}{\lambda} \cong \frac{1240 \text{ eV} \cdot \text{nm}}{\lambda}$$

3. Bohr's Model

$$(a) \text{ Bohr quantization rule} \quad mvr = n \cdot \frac{h}{2\pi} = n \cdot \hbar$$

$$(b) E_n = \frac{E_1}{n^2} Z^2 = -\frac{2\pi^2 m e^4 K^2}{n^2 h^2} Z^2; \quad E_1 = \frac{-2\pi^2 m e^4 K^2 Z^2}{h^2}$$

$$(c) r_n = \frac{h^2}{4\pi^2 e^2 m K} \times \frac{n^2}{Z}$$

$$(d) v_n = \frac{2\pi e^2 K}{h} \times \frac{Z}{n}$$

$$(e) \text{ Revolutions per sec} = v/2\pi r$$

4. **Spectral lines**

- (a) Rydberg's Equation $\frac{1}{\lambda} = \bar{\nu} = R_H \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right] \times Z^2$; $R_H \cong 109700 \text{ cm}^{-1}$
- (b) For First line of a series $n_2 = n_1 + 1$ (Also known as α line)
- (c) H_α line means $n_2 = n_1 + 1$; also known as line of longest λ , shortest ν , least E
- (d) Number of spectral line observed in the spectrum = $\frac{n(n-1)}{2}$
when e^- de-excites to ground state, n = number of higher orbit

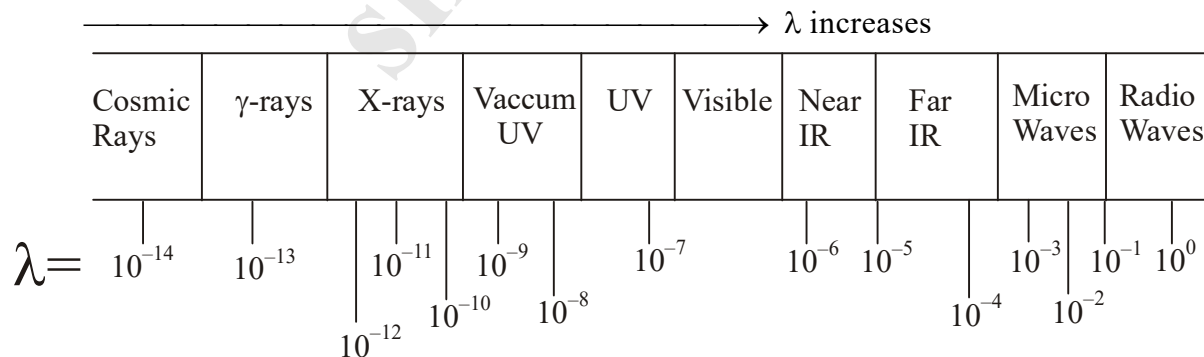
5. **Photoelectric effect**

- (a) Kinetic energy = $h\nu - w = h\nu - h\nu_0$
where w = work function
 ν_0 = Threshold frequency
- (b) Accelerating potential = $eV = KE = \frac{1}{2}mv^2$
- (c) $\nu^{1/2} = a(z-b)$ b = screening constant

6. **De-broglie, Heisenberg & Schrodinger equations**

- (a) Number of waves = n = principal quantum number
- (b) $\lambda = h/mv = h/p$
- (c) wavelength of electron (λ) $\cong \sqrt{\frac{150}{V \text{ in volts}}} \text{ \AA}$
- (d) $\Delta x \cdot \Delta p \geq h/4\pi$
- (e) Orbital angular momentum = $\frac{h}{2\pi} \sqrt{l(l+1)}$
- (f) Spin angular momentum = $\frac{h}{2\pi} \sqrt{S(S+1)}$
- (g) Magnetic moment (μ) = $\sqrt{n(n+2)}$ B.M. ; n = number of unpaired electron
- (h) Radial Nodes = $(n - l - 1)$
- (i) Angular nodes = l
- (j) Total nodes = $(n-1)$

7. **Electromagnetic Spectrum**



LAST MOMENT REVIEW

**ATOMIC STRUCTURE
& GENERAL CHEMISTRY**

Theory :

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Exercise - 1 : Question

Exercise - 2 : Question

Exercise - 3 : Question

Exercise - 4 : Question

DPPs :

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Other Sources :

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Assertion Reason

- Q.20 **Statement-1:** Energy emitted when an electron jump from $5 \rightarrow 2$ (energy level) is less than when an electron jump from $2 \rightarrow 1$ in all 'H' like atom.
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Comprehension :**Paragraph for question nos. 21 to 23**

An unknown orbital is having the following equation for its wavefunction.

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where $\sigma = \frac{2Zr}{a_0}$, a_0 is constant = 0.529 Å and all other parameters have usual meaning. Based on this data answer the question that follow.

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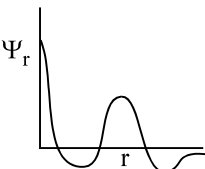
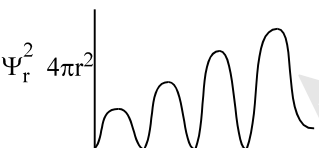
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Column I	Column II
(A) Orbital angular momentum of the electron in a hydrogen-like atomic orbital	(P) Principal quantum number
(B) A hydrogen-like one-electron wave function obeying Pauli principle	(Q) Azimuthal quantum number
(C) Shape, size and orientation 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

[Ans. (A) Q,R (B) P, Q, R,S (C) P, Q, R (D) P, Q]

Q.25 Column I & column II contain data on Schrodinger Wave-Mechanical model, where symbols have their usual meanings. Match the columns.

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

[Ans. (A) P, (B) P,Q,S, (C) P, R (D) Q, S]

Subjective :

Q.26 Find the product of multiplication of number of electrons corresponding to $(n + l) = 3$ and $l = 2$ in Cu (29). [Ans. 80]

Q.27 Electrons in a sample of H-atoms make transitions from state $n = X$ to some lower excited state. The emission spectrum from the sample is found to contain only the lines belonging to a particular series. If one of the photons had an energy of 0.6375 eV, then find out value of X.

[Take $0.6375 \text{ eV} = \frac{3}{4} \times 0.85 \text{ eV}$] [Ans. 8]

Q.28 A sample of hydrogen atoms in ground state absorbs light of $x \text{ nm}$. If the excited sample emits the radiations of six different photon energies but the detector of these emitted radiations has not detected ultraviolet radiations, then the value of 'x' is (Given : $R_H = \frac{1}{96} \times 10^9 \text{ m}^{-1}$) [Ans. 0100]

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Info C = Azimuthal quantum number of subshell to orbital belongs

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Info E = Orbital angular momentum of given orbital.

Info F = Radial distance of the spherical node which is farthest from the nucleus

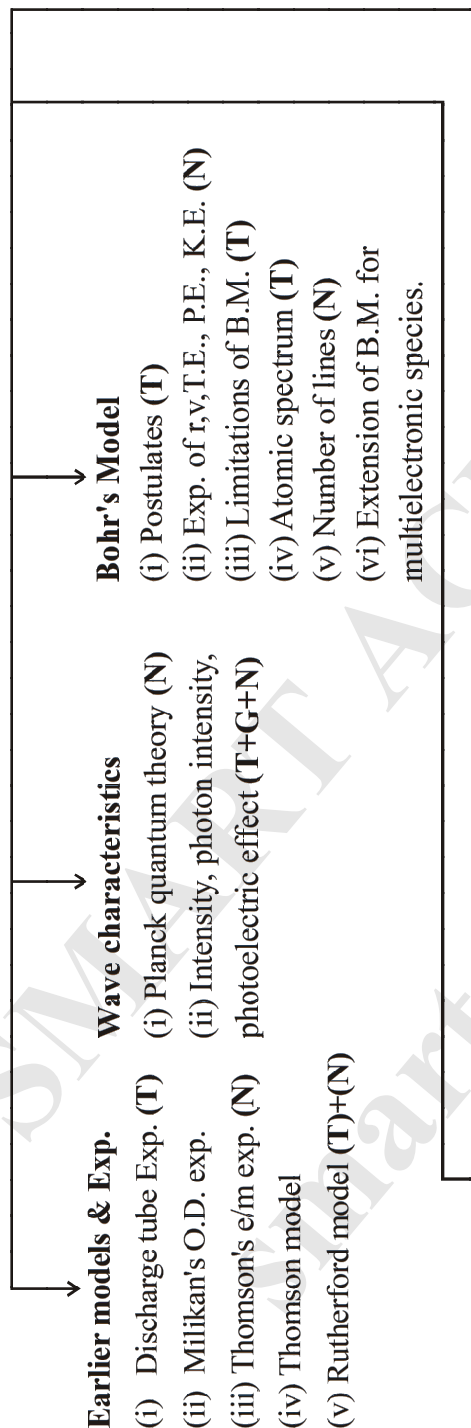
(Assuming $k_3 = 1$)

[Ans.300303]

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Atomic structure



Earlier models & Exp.

- (i) Discharge tube Exp. (T)
- (ii) Millikan's O.D. exp.
- (iii) Thomson's e/m exp. (N)
- (iv) Thomson model
- (v) Rutherford model (T)+(N)

Wave characteristics

- (i) Planck quantum theory (N)
- (ii) Intensity, photon intensity, photoelectric effect (T+G+N)

Bohr's Model

- (i) Postulates (T)
- (ii) Exp. of r,v,T.E., P.E., K.E. (N)
- (iii) Limitations of B.M. (T)
- (iv) Atomic spectrum (T)
- (v) Number of lines (N)
- (vi) Extension of B.M. for multielectronic species.

Wave Mechanical Model

- (i) DeBroglie & Heisenberg (T + N)
- (ii) Theoretical concepts/assumptions (T)
- (iii) Ψ , Ψ^2 & $\Psi^2 dV$ (N)
- (iv) Radial prob. curves, radial nodes (T)+(G)
- (v) Angular prob. curves (T)+(G)

Quantum numbers & Electronic configuration

- (i) Significance of each quantum number (T)
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Gas constant	R	8.3145 J/mol-K	0.0821 atm-lit / mol / K

Energy Conversion Factors

$$1 \text{ erg} = 10^{-7} \text{ J}$$

$$1 \text{ cal} = 4.184 \text{ J}$$

$$1 \text{ eV} = 1.602177 \times 10^{-19} \text{ J} = 1.602177 \times 10^{-12} \text{ erg} = 23.0605 \text{ kcal/mol}$$

STRUCTURE OF ATOM**1. Rutherford's Model**

$$(a) R_n = R_1 (A)^{1/3}, \quad R_1 = 1.33 \times 10^{-13} \text{ cm} \quad A = \text{mass number} \quad R_n = \text{Radius of nucleus}$$

$$(b) \frac{1}{2} m_\alpha v_\alpha^2 = K \frac{Z \cdot 2e}{r}; \quad r = \text{distance of closest approach}, \quad v_\alpha = \text{initial velocity of a } \alpha\text{-particle}$$

2. Light

(a) Photon is considered massless bundle of energy.

$$(b) E = mc^2$$

$$(c) E_{\text{photon}} = hv = hc/\lambda = hc \bar{\nu}$$

$$(d) E = \frac{hc}{\lambda} \cong \frac{1240 \text{ eV} \cdot \text{nm}}{\lambda}$$

3. Bohr's Model

$$(a) \text{ Bohr quantization rule} \quad mvr = n \cdot \frac{h}{2\pi} = n \cdot \hbar$$

$$(b) E_n = \frac{E_1}{n^2} Z^2 = -\frac{2\pi^2 m e^4 K^2}{n^2 h^2} Z^2; \quad E_1 = \frac{-2\pi^2 m e^4 K^2 Z^2}{h^2}$$

$$(c) r_n = \frac{h^2}{4\pi^2 e^2 m K} \times \frac{n^2}{Z}$$

$$(d) v_n = \frac{2\pi e^2 K}{h} \times \frac{Z}{n}$$

$$(e) \text{ Revolutions per sec} = v/2\pi r$$

4. **Spectral lines**

- (a) Rydberg's Equation $\frac{1}{\lambda} = \bar{\nu} = R_H \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right] \times Z^2$; $R_H \cong 109700 \text{ cm}^{-1}$
- (b) For First line of a series $n_2 = n_1 + 1$ (Also known as α line)
- (c) H_α line means $n_2 = n_1 + 1$; also known as line of longest λ , shortest ν , least E
- (d) Number of spectral line observed in the spectrum = $\frac{n(n-1)}{2}$
when e^- de-excites to ground state, n = number of higher orbit

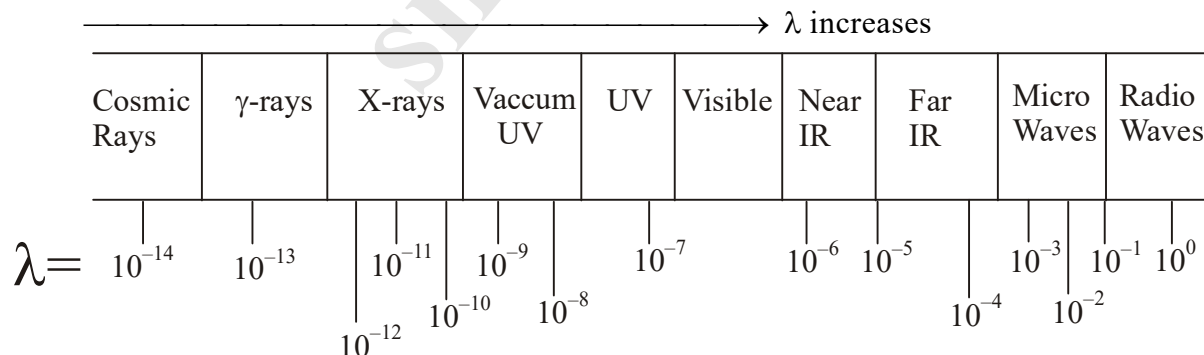
5. **Photoelectric effect**

- (a) Kinetic energy = $h\nu - w = h\nu - h\nu_0$
where w = work function
 ν_0 = Threshold frequency
- (b) Accelerating potential = $eV = KE = \frac{1}{2}mv^2$
- (c) $\nu^{1/2} = a(z-b)$ b = screening constant

6. **De-broglie, Heisenberg & Schrodinger equations**

- (a) Number of waves = n = principal quantum number
- (b) $\lambda = h/mv = h/p$
- (c) wavelength of electron (λ) $\cong \sqrt{\frac{150}{V \text{ in volts}}} \text{ \AA}$
- (d) $\Delta x \cdot \Delta p \geq h/4\pi$
- (e) Orbital angular momentum = $\frac{h}{2\pi} \sqrt{l(l+1)}$
- (f) Spin angular momentum = $\frac{h}{2\pi} \sqrt{S(S+1)}$
- (g) Magnetic moment (μ) = $\sqrt{n(n+2)}$ B.M. ; n = number of unpaired electron
- (h) Radial Nodes = $(n - l - 1)$
- (i) Angular nodes = l
- (j) Total nodes = $(n-1)$

7. **Electromagnetic Spectrum**



LAST MOMENT REVIEW

**ATOMIC STRUCTURE
& GENERAL CHEMISTRY**

Theory :

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Exercise - 1 : Question

Exercise - 2 : Question

Exercise - 3 : Question

Exercise - 4 : Question

DPPs :

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Other Sources :

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