Exercise-1

✍ **Marked questions are recommended for Revision.**

PART - I : SUBJECTIVE QUESTIONS

Section (A) : Discovery of sub atomic particles, Atomic models, nucleus

Commit to memory :

Q = ne (charge is quantized)

P.E. = $\frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r}$

Mass number of an element = No. of protons (Z) + No. of neutrons (n).

Closest distance (r) = $\frac{4KZe^2}{m_\alpha v_\alpha^2}$

A-1. Complete the following table :

Particle	Atomic No.	Mass No.	No. of electrons	No. of protons	No. of neutrons
Sodium atom	11	---	---	---	12
Aluminium ion	---	27	10	---	---
Chloride ion	---	---	18	---	18
Phosphorus atom	---	31	---	15	---
Cuprous ion	---	---	28	---	35

A-2. If radius of the nucleus is 3.5×10^{-15} m then find the space or volume occupied by the nucleus.

A-3.✍ The approximate radius of a H-atom is 0.05 nm, and that of proton is 1.5×10^{-15} m. Assuming both the hydrogen atom and the proton to be spherical, calculate fraction of the space in an atom of hydrogen that is occupied by the nucleus.

A-4.✍ (A) Find the radius of nucleus of an atom having atomic mass number equal to 125. (Take $R_0=1.3\times10^{-15}$ m)
(B) Find the distance of closest approch when an α particle is projected towards the nucleus of silver atom having speed v. (mass of α particle = m_α, atomic number of Ag = 47)

A-5. Write the conclusions of observations of Rutherford's experiment.

Section (B) : Quantum theory of light & Photoelectric Effect

Commit to memory :

Q = ne (charge is quantized)

$\bar{\nu} = \frac{1}{\lambda}$

$v = \nu \times \lambda$

$E_0 = h\nu$ (ν - Frequency of light)

$E_0 = \frac{hc}{\lambda}$ (c - speed of light)

$h\nu = h\nu_0 + \frac{1}{2}m_e v^2$

B-1. Calculate the energy of 100 photons if the wavelength of the light is 2000Å.

B-2. How many photons are emitted per second by a 5 mW laser operating at 620 nm?

B-3. The Vividh Bharati Station of All India Radio, Delhi broadcasts on a frequency of 1368 kHz (kilo hertz). Calculate the wavelength and wave number of the electromagnetic radiation emitted by the transmitter.

B-4.✍ One quantum is absorbed per gaseous molecule of Br_2 for converting into Br atoms. If light absorbed has wavelength 5000 Å, calculate energy required in kJ/mol.

B-5. The eyes of a certain member of the reptile family pass a 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? ($h = 6.6 \times 10^{-34}$)

B-6. Two bulbs 'A' and 'B' emit red light and yellow light at 8000 Å and 4000Å respectively. The number of photons emitted by both the bulbs per second is the same. If the red bulb is labelled as 100 watts, find the wattage of the yellow bulb.

B-7. If a light with frequency 4×10^{16} Hz emitted photoelectrons with double the maximum kinetic energy as are emitted by the light of frequency 2.5×10^{16} Hz from the same metal surface, then what is the threshold frequency (ν_0) of the metal ?

Section (C) : Bohr Model

Commit to memory :

- $\frac{mv^2}{r} = \frac{Ke^2Z}{r^2}$
- $mvr = \frac{nh}{2\pi}$
- $\frac{hc}{\lambda} = \Delta E$
- $\upsilon = \frac{\Delta E}{h}$
- $r = \frac{n^2h^2}{4\pi^2 mKZe^2}$
- $r_n = 0.529 \times \frac{n^2}{Z}$ Å
- $v = \frac{2\pi Ze^2K}{nh}$
- $v_n = 2.18 \times 10^6 \times \frac{Z}{n}$ m/sec
- $T = \frac{2\pi r}{v}$
- $f = \frac{v}{2\pi r}$
- T.E. = $E_n = -\frac{2\pi^2 me^4k^2}{h^2}\left(\frac{z^2}{n^2}\right)$
- $E_n = -13.6 \frac{Z^2}{n^2}$ eV/atom
- $E_n = -2.18 \times 10^{-18} \frac{Z^2}{n^2}$ J/atom
- T.E. = $\frac{1}{2}$ P.E.
- T.E. = – K.E.

C-1. Which state of the triply ionized Beryllium (Be^{3+}) has the same orbit radius as that of the ground state of hydrogen atom ?

C-2. If the velocity of the electron in first orbit of H atom is 2.18×10^6 m/s, what is its value in third orbit ?

C-3. Consider Bohr's theory for hydrogen atom. The magnitude of angular momentum, orbit radius and velocity of the electron in n^{th} energy state in a hydrogen atom are ℓ, r & v respectively. Find out the value of 'x', if product of v, r and ℓ ($vr\ell$) is directly proportional to n^x.

C-4. Find the ratio of the time period of 2^{nd} Bohr orbit of He^+ amd 4^{th} Bohr orbit of Li^{2+}.

C-5. Consider three electron jumps described below for the hydrogen atom

x : n = 3 to n = 1
y : n = 4 to n = 2
z : n = 5 to n = 3

The photon emitted in which transition x, y or z will have shortest wavelength.

C-6. A hydrogen sample is prepared in a particular excited state. Photons of energy 2.55 eV get absorbed into the sample to take some of the electrons to a further excited state B. Find orbit numbers of the states A and B. Given the allowed energies of hydrogen atom :

$E_1 = -13.6$ eV, $E_2 = -3.4$ eV, $E_3 = -1.5$ eV, $E_4 = -0.85$ eV, $E_5 = -0.54$ eV

C-7. A single electron ion has nuclear charge + Ze where Z is atomic number and e is electronic charge. It requires 16.52 eV to excite the electron from the second Bohr orbit to third Bohr orbit. Find
(a) The atomic number of element?
(b) The energy required for transition of electron from first to third orbit?
(c) Wavelength of photon required to remove electron from first Bohr orbit to infinity?
(d) The kinetic energy of electron in first Bohr orbit?

C-8. The excitation energy of first excited state of a hydrogen like atom is 40.8 eV. Find the energy needed to remove the electron to form the ion.

Section (D) : Spectrum

Commit to memory :

- $\frac{1}{\lambda} = \bar{\nu} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

  R = Rydberg constant = 1.09678×10^7 m^{-1}
- Number of different line produce = $\frac{\Delta n \ (\Delta n + 1)}{2}$, where $\Delta n = n_2 - n_1$

  n_2 = higher energy orbit, n_1 = lower energy orbit
- For single isolated atom max. number of spectral lines observed = (n – 1)

D-1. Calculate the two longest wavelengths of the radiation emitted when hydrogen atoms make transitions from higher states to n = 2 state.

D-2. What electron transition in the He^+ spectrum would have the same wavelength as the first Lyman transition of hydrogen?

D-3. Calculate the frequency of light emitted for an electron transition from the sixth to second orbit of the hydrogen atom. In what region of the spectrum does this light occur?

D-4. At what atomic number would a transition from n = 2 to n = 1 energy level result in emission of photon of $\lambda = 3 \times 10^{-8}$ m.

D-5. In a container a mixture is prepared by mixing of three samples of hydrogen, helium ion (He^+) and lithium ion (Li^{2+}). In sample all the hydrogen atoms are in 1st excited state and all the He^+ ions are in third excited state and all the Li^{2+} ions are in fifth excited state. Find the total number of spectral lines observed in the emission spectrum of such a sample, when the electrons return back upto the ground state.

Section (E) : De-broglie wavelength and Heisenberg uncertainity principle

Commit to memory

- $\lambda = \frac{h}{mv}$
- $\lambda = \frac{h}{\sqrt{2emV}}$
- $\lambda = \frac{12.3}{\sqrt{V}}$ Å
- $\Delta x \,.\, \Delta p \geq \frac{h}{4\pi}$ or $\Delta x.(m\Delta v) \geq \frac{h}{4\pi}$
- $\Delta E.\Delta t \geq \frac{h}{4\pi}$.

E-1. An electron in a H-atom in its ground state absorbs 1.5 times as much energy as the minimum required for its escape (13.6 eV) from the atom. What is wavelength of the emitted electron.

E-2. Deduce the condition when the De-Broglie wavelength associated with an electron would be equal to that associated with a proton if a proton is 1836 times heavier than an electron.

E-3. An electron, practically at rest, is initially accelerated through a potential difference of 100 volts. It then has a de Broglie wavelength = λ_1 Å. It then get retarded through 19 volts and then has a wavelength λ_2 Å. A further retardation through 32 volts changes the wavelength to λ_3Å, What is $\frac{\lambda_3 - \lambda_2}{\lambda_1}$?

E-4. If an electron having kinetic energy 2 eV is accelerated through the potential difference of 2 Volt. Then calculate the wavelength associated with the electron.

E-5. The uncertainty in position and velocity of the particle are 0.1 nm and 5.27×10^{-24} ms^{-1} respectively then find the mass of the particle. ($h = 6.625 \times 10^{-34}$Js)

Section (F) : Quantum mechanical model of atom, Shrodinger wave equation and orbital concept

Commit to memory :

- $\frac{\delta^2\psi}{\delta x^2} + \frac{\delta^2\psi}{\delta y^2} + \frac{\delta^2\psi}{\delta z^2} + \frac{8\pi^2 m}{h^2}(E - V)\,\psi = 0$
- Radial nodes = $n - \ell - 1$,
- Angular nodes = ℓ,
- Total nodes = $n - 1$

F-1. Find : (a) The number of radial nodes of 5s atomic orbital
(b) The number of angular nodes of $3d_{yz}$ atomic orbital
(c) The sum of angular nodes and radial nodes of $4d_{xy}$ atomic orbital
(d) The number of angular nodes of 3p atomic orbital

F-2. An electron in a hydrogen atom finds itself in the fourth energy level.
(i) Write down a list of the orbitals that it might be in.
(ii) Can it be in all of these orbitals at once ?
(iii) Can you tell which orbital it is in ?

Section (G) : Quantum numbers & Electronic configuration

Commit to memory :

- Number of subshell present in n^{th} shell = n
- Number of orbitals present in n^{th} shell = n^2.
- The maximum number of electrons in a principal energy shell = $2n^2$.
- Angular momentum of any orbit = $\frac{nh}{2\pi}$
- Number of orbitals in a subshell = $2\ell + 1$
- Maximum number of electrons in particular subshell = $2 \times (2\ell + 1)$
- $L = \frac{h}{2\pi}\sqrt{\ell(\ell+1)} = \hbar\sqrt{\ell(\ell+1)}$ $\left[\hbar = \frac{h}{2\pi}\right]$
- Orbitals present in a main energy level is 'n^2'.
- $\mu = \sqrt{n(n+2)}$ B.M.
- Spin angular momentum = $\frac{h}{2\pi}\sqrt{s(s+1)}$
- Maximum spin of atom = $\frac{1}{2}$ × No. of unpaired electron.

G-1. How many unpaired electrons are there in Ni^{+2} ion if the atomic number of Ni is 28.

G-2. Write the electronic configuration of the element having atomic number 56.

G-3. Given below are the sets of quantum numbers for given orbitals. Name these orbitals.

(a)	(b)	(c)	(d)	(e)
n = 3	n = 5	n = 4	n = 2	n = 4
ℓ = 1	ℓ = 2	ℓ = 1	ℓ = 0	ℓ = 2

G-4. Point out the angular momentum of an electron in,
(a) 4s orbital (b) 3p orbital (c) 4^{th} orbit (according to Bohr model)

G-5. Which of the following sets of quantum numbers are impossible for electrons? Explain why in each case.

Set	n	ℓ	m	s
(i)	1	0	1	$+\frac{1}{2}$
(ii)	3	0	0	$-\frac{1}{2}$
(iii)	1	2	2	$+\frac{1}{2}$
(iv)	4	3	–3	$+\frac{1}{2}$
(v)	5	2	1	$-\frac{1}{2}$
(v)	3	2	1	0

G-6. Find the total spin and spin magnetic moment of following ion.
(i) Fe^{+3} (ii) Cu^{+}

Section (H) : Nuclear chemistry

Commit to memory :
- α : $_2He^4$ ($_2{}^4He^{2+}$) (nucleus of He-atom)
- β or β^- : $_{-1}e^0$ (fast moving electron emitted from nucleus)
- γ : $_0\gamma^0$ (electromagnetic radiation (waves) of high frequency)
- $\Delta E = \Delta m \times 931.478$ MeV

H-1. Calculate the loss in mass during the change:

$$^{7}_{3}Li + ^{1}_{1}H \longrightarrow 2\,^{4}_{2}He + 17.25 \text{ MeV}$$

H-2. When ^{24}Mg is bombarded with neutron then a proton is ejected. Complete the equation and report the new element formed.

H-3. Write equations for the following transformation :
(a) $^{14}_{7}N$ (n, p) (b) $^{39}_{19}K$ (n, α)

H-4. Explain with reason the nature of emitted particle by :
(a) $^{38}_{20}Ca$ (b) $^{35}_{18}Ar$ (c) $^{80}_{32}Ge$ (d) $^{40}_{20}Ca$

H-5. For the given series reaction in n^{th} step, find out the number of produced neutrons & energy.

$$^{238}_{92}U \longrightarrow Ba + Kr + 3\,_0n^1 + \text{Energy (E)}$$

PART - II : ONLY ONE OPTION CORRECT TYPE

Section (A) : Discovery of sub atomic particles, Atomic models, nucleus

A-1. The element having no neutron in the nucleus of its atom is
(A) Hydrogen (B) Nitrogen (C) Helium (D) Boron

A-2. The mass of cathode ray particle is :
(A) Same for different gases (B) Different for different gases
(C) Minimum for H_2 gas (D) Different for same gases

A-3. The ratio of the "e/m" (specific charge) values of a electron and an α-particle is -
(A) 2 : 1 (B) 1 : 1 (C) 1 : 2 (D) None of these

A-4. Rutherford's alpha particle scattering experiment eventually led to the conclusion that
(A) mass and energy are related
(B) electrons occupy space around the nucleus
(C) neutrons are buried deep in the nucleus
(D) the point of impact with matter can be precisely determined

A-5. 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}

A-6. The approximate size of the nucleus of $^{64}_{28}Ni$ is :
(A) 3 fm (B) 4 fm (C) 5 fm (D) 2 fm

Section (B) : Quantum theory of light & Photoelectric Effect

B-1. The MRI (magentic resonance imaging) body scanners used in hospitals operate with 400 MHz radio frequency. The wavelength corresponding to this radio frequency is:
(A) 0.75 m (B) 0.75 cm (C) 1.5 m (D) 2 cm

B-2. Photon of which light has maximum energy :
(A) red (B) blue (C) violet (D) green

B-3. Electromagnetic radiations of wavelength 242 nm is just sufficient to ionise Sodium atom. Then the ionisation energy of Sodium in kJ $mole^{-1}$ is.
(A) 494.65 (B) 400 (C) 247 (D) 600

B-4. A bulb of 40 W is producing a light of wavelength 620 nm with 80% of efficiency then the number of photons emitted by the bulb in 20 seconds are ($1eV = 1.6 \times 10^{-19}$ J, hc = 12400 eV Å)
(A) 2×10^{18} (B) 10^{18} (C) 10^{21} (D) 2×10^{21}

B-5. Light of wavelength λ falls on metal having work function hc/λ_0. Photoelectric effect will take place only if :
(A) $\lambda \geq \lambda_0$ (B) $\lambda \geq 2\lambda_0$ (C) $\lambda \leq \lambda_0$ (D) $\lambda \leq \lambda_0/2$

B-6. A photon of energy $h\nu$ is absorbed by a free electron of a metal having work function $w < h\nu$. Then :
(A) The electron is sure to come out
(B) The electron is sure to come out with a kinetic energy $(h\nu - w)$
(C) Either the electron does not come out or it comes with a kinetic energy $(h\nu - w)$
(D) It may come out with a kinetic energy less than $(h\nu - w)$

Section (C) : Bohr Model

C-1. Correct order of radius of the Ist orbit of H, He^+, Li^{2+}, Be^{3+} is :
(A) $H > He^+ > Li^{2+} > Be^{3+}$ (B) $Be^{3+} > Li^{2+} > He^+ > H$
(C) $He^+ > Be^{3+} > Li^{2+} > H$ (D) $He^+ > H > Li^{2+} > Be^{3+}$

C-2. What is likely to be orbit number for a circular orbit of diameter 20 nm of the hydrogen atom :
(A) 10 (B) 14 (C) 12 (D) 16

C-3. 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

C-4. If velocity of an electron in I orbit of H atom is V, what will be the velocity of electron in 3rd orbit of Li^{+2}
(A) V (B) V/3 (C) 3 V (D) 9 V

C-5. In a certain electronic transition in the hydrogen atoms from an initial state (1) to a final state (2), the difference in the orbital radius $(r_1 - r_2)$ is 24 times the first Bohr radius. Identify the transition.
(A) $5 \rightarrow 1$ (B) $25 \rightarrow 1$ (C) $8 \rightarrow 3$ (D) $6 \rightarrow 5$

C-6. 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) 54.4 V
(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)

C-7. **S_1 :** Potential energy of the two opposite charge system increases with the decrease in distance.
S_2 : When an electron make transition from higher orbit to lower orbit it's kinetic energy increases.
S_3 : When an electron make transtition from lower energy to higher energy state its potential energy increases.
S_4 : 11eV photon can free an electron from the 1st excited state of He^+ ion.
(A) T T T T (B) F T T F (C) T F F T (D) F F F F

Section (D) : Spectrum

D-1. The energy of hydrogen atom in its ground state is –13.6 eV. The energy of the level corresponding to n = 5 is:
(A) –0.54 eV (B) –5.40 eV (C) –0.85 eV (D) –2.72 eV

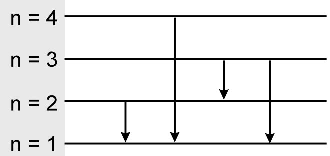
D-2. The wavelength of a spectral line for an electronic transition is inversely proportional to :
(A) number of electrons undergoing transition
(B) the nuclear charge of the atom
(C) the velocity of an electron undergoing transition
(D) the difference in the energy involved in the transition

D-3. In a sample of H-atom electrons make transition from 5th excited state upto ground state, producing all possible types of photons, then number of lines in infrared region are
(A) 4 (B) 5 (C) 6 (D) 3

D-4. 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)

D-5. No. of visible lines when an electron returns from 5th orbit upto ground state in H spectrum :
(A) 5 (B) 4 (C) 3 (D) 10

D-6. Suppose that a hypothetical atom gives a red, green, blue and violet line spectrum. Which jump according to figure would give off the red spectral line.



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

D-7. The difference between the wave number of 1st line of Balmer series and last line of paschen series for Li^{2+} ion is :
(A) $\frac{R}{36}$ (B) $\frac{5R}{36}$ (C) 4R (D) $\frac{R}{4}$

Section (E) : De-broglie wavelength and Heisenberg uncertainity principle

E-1. The approximate wavelength associated with a gold-ball weighing 200 g and moving at a speed of 5 m/hr is of the order of
(A) 10^{-1} m (B) 10^{-20} m (C) 10^{-30} m (D) 10^{-40} m

E-2. What possibly can be the ratio of the de Broglie wavelengths for two electrons each having zero initial energy and accelerated through 50 volts and 200 volts ?
(A) 3 : 10 (B) 10 : 3 (C) 1 : 2 (D) 2 : 1

E-3. In H-atom, if 'x' is the radius of the first Bohr orbit, de Broglie wavelength of an electron in 3rd orbit is:
(A) $3\pi x$ (B) $6\pi x$ (C) $\frac{9x}{2}$ (D) $\frac{x}{2}$

E-4. An α-particle is accelerated through a potential difference of V volts from rest. The de-Broglie's wavelength associated with it is :

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

E-5. de-Broglie wavelength of electron in second orbit of Li^{2+} ion will be equal to de-Broglie of wavelength of electron in

(A) n = 3 of H-atom (B) n = 4 of C^{5+} ion (C) n = 6 of Be^{3+} ion (D) n = 3 of He^{+} ion

E-6. The wavelength of a charged particle ________the square root of the potential difference through which it is accelerated:

(A) is inversely proportional to (B) is directly proportional to
(C) is independent of (D) is unrelated with

E-7. The uncertainty in the momentum of an electron is 1.0×10^{-5} kg m s^{-1}. The uncertainty in its position will be: ($h = 6.626 \times 10^{-34}$ Js)

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

Section (F) : Quantum mechanical model of atom, Shrodinger wave equation and orbital concept

F-1. The correct time independent Schrödinger's wave equation for an electron with E as total energy and V as potential energy is :

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

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

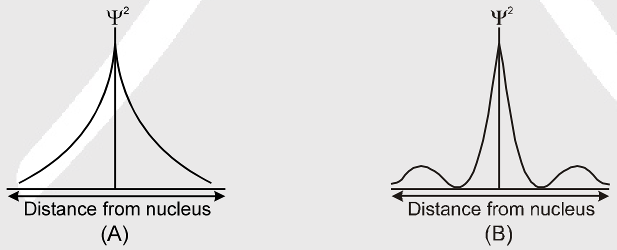
(C) $\frac{\partial^2\psi}{\partial x^2}+\frac{\partial^2\psi}{\partial y^2}+\frac{\partial^2\psi}{\partial z^2}+\frac{8\pi^2 m}{h^2}(E-V)\psi=0$

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

F-2. The maximum radial probability in 1s-orbital occurs at a distance when : [r_0 = Bohr radius]

(A) $r = r_0$ (B) $r = 2r_0$ (C) $r = \frac{r_0}{2}$ (D) $2r = \frac{r_0}{2}$

F-3. Consider following figure A and B indicating distribution of charge density (electron probability Ψ^2) with distance r.



Select the correct statement:

(A) A and B both are for 1s (B) A and B both are for 2s
(C) A is for 2s, B is for 1s (D) A is for 1s, B is for 2s

F-4. The maximum probability of finding electron in the d_{xy} orbital is :

(A) Along the x-axis (B) Along the y-axis
(C) At an angle of 45^0 from the x and y axis (D) At an angle of 90^0 from the x and y axis.

F-5. $3p_y$ orbital has..........nodal plane :

(A) XY (B) YZ (C) ZX (D) All of these

F-6. A 3p-orbital has

(A) Two non-spherical nodes (B) Two spherical nodes
(C) One spherical and one non spherical nodes (D) One spherical and two non spherical nodes

F-7. According to Schrodinger model nature of electron in an atom is as :
(A) Particle only (B) Wave only
(C) Particle and wave nature simultaneous (D) Sometimes waves and sometimes particle

F-8. Consider the following statements:
(a) Electron density in the XY plane in $3d_{x^2-y^2}$ orbital is zero
(b) Electron density in the XY plane in $3d_{z^2}$ orbital is zero.
(c) 2s orbital has one nodal surface
(d) for $2p_z$ orbital, XY is the nodal plane.
Which of these are incorrect statements:
(A) a & c (B) b & c (C) Only b (D) a, b

F-9. Which of the following d-orbitals has dough-nut shape ?
(A) d_{xy} (B) d_{yz} (C) $d_{x^2-y^2}$ (D) d_{z^2}

F-10. The permissible solution to the schrodinger wave equation gave an ideal of .... Quantum number
(A) 4 (B) 3 (C) 2 (D) 1

Section (G) : Quantum numbers & Electronic configuration

G-1. The orbital with zero orbital angular momentum is :
(A) s (B) p (C) d (D) f

G-2. 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) $[Ar] 3d^9$

G-3. Spin magnetic moment of X^{n+} (Z = 26) is $\sqrt{24}$ B.M. Hence number of unpaired electrons and value of n respectively are :
(A) 4, 2 (B) 2, 4 (C) 3, 1 (D) 0, 2

G-4. Which of the following ions has the maximum number of unpaired d-electrons?
(A) Zn^{2+} (B) Fe^{2+} (C) Ni^{3+} (D) Cu^{+}

G-5. The total spin resulting from a d^7 configuration is :
(A) 1 (B) 2 (C) 5/2 (D) 3/2

G-6. Given is the electronic configuration of element X :

K	L	M	N
2	8	11	2

The number of electrons present with ℓ = 2 in an atom of element X is :
(A) 3 (B) 6 (C) 5 (D) 4

G-7. Consider the ground state of Cr atom (Z = 24). The numbers of electrons with the azimuthal quantum numbers, ℓ = 1 and 2 are, respectively:
(A) 16 and 5 (B) 12 and 5 (C) 16 and 4 (D) 12 and 4

G-8. The orbital angular momentum of an electron in 2s-orbital is :
(A) $+\frac{1}{2}\frac{h}{2\pi}$ (B) zero (C) $\frac{h}{2\pi}$ (D) $\sqrt{2}\frac{h}{2\pi}$

G-9. The possible value of 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

G-10. For an electron, with n = 3 has only one radial node. The orbital angular momentum of the electron will be
(A) 0 (B) $\sqrt{6}\frac{h}{2\pi}$ (C) $\sqrt{2}\frac{h}{2\pi}$ (D) 3

Section (H) : Nuclear chemistry

H-1. $^{11}_{6}C$ on decay produces :
(A) Positron (B) β-particle (C) α-particle (D) none of these

H-2. $^{60}_{27}Co$ is radioactive because :
(A) Its atomic number is high (B) it has high p/n ratio
(C) it has high n/p ratio (D) none of these

H-3. Consider α-particles, β-particles and γ-rays, each having an energy of 0.50 MeV. The increasing order of penetration power is :
(A) $\alpha < \beta < \gamma$ (B) $\alpha < \gamma < \beta$ (C) $\beta < \gamma < \alpha$ (D) $\gamma < \beta < \alpha$

H-4. $^{27}_{13}Al$ is a stable isotope. $^{29}_{13}Al$ is expected to disintegrate by :
(A) α-emission (B) β-emission (C) positron emission (D) proton emission

H-5. Which of the following nuclear emission will generate an isotope :
(A) β-emission (B) neutron emission (C) α-emission (D) positron emission

H-6. The total number of α- and β-particles given out during given nuclear transformation is :

$$^{238}_{92}U \longrightarrow {}^{214}_{82}Pb$$

(A) 2 (B) 4 (C) 6 (D) 8

PART - III : MATCH THE COLUMN

1. **List-I** and **List-II** contains six entries each. Entries of **List-I** are to be matched with some entries of **List-II**.

	List-I		List-II
(i)	Cathode rays	(a)	Helium nuclei
(ii)	Dumb-bell	(b)	Uncertainty principle
(iii)	Alpha particles	(c)	Electromagnetic radiation
(iv)	Moseley	(d)	p-orbital
(v)	Heisenberg	(e)	Atomic number
(vi)	X-rays	(f)	Electrons

2. Frequency = f, Time period = T, Energy of nth orbit = E_n, radius of nth orbit = r_n, Atomic number = Z, Orbit number = n

	List-I		List-II
(i)	f	(p)	n^3
(ii)	T	(q)	Z^2
(iii)	E_n	(r)	$\frac{1}{n^2}$
(iv)	$\frac{1}{r_n}$	(s)	Z

3. **List-I** and **List-II** contains six entries each. Entries of **List-I** are to be matched with some entries of **List-II**.

	List-I		List-II
(i)	Aufbau principle	(p)	Line spectrum in visible region
(ii)	de broglie	(q)	Maximum multiplicity of electron
(iii)	Angular momentum	(r)	Photon
(iv)	Hund's rule	(s)	$\lambda = h/(mv)$
(v)	Balmer series	(t)	Electronic configuration
(vi)	Planck's law	(u)	mvr

4. Match List-I with List-II and select the correct answer using the codes given below in the lists (n, ℓ and m are respectively the principal, azimuthal and magnetic quantum no.)

	List-I		List-II
(A)	Number of value of ℓ for an energy level(n)	(p)	0, 1, 2, ... (n - 1)
(B)	Values of ℓ for a particular type of orbit	(q)	$+\ell$ to $-\ell$ through zero
(C)	Number of value of m for $\ell = 2$	(r)	5
(D)	Values of 'm' for a particular type of orbital	(s)	n

Exercise-2

Marked questions are recommended for Revision.

PART - I : ONLY ONE OPTION CORRECT TYPE

1. Which is not true with respect to cathode rays ?
(A) A stream of electrons (B) Charged particles
(C) Move with same speed as that of light (D) Can be deflected by electric field

2. The mass to charge ratio (m/e) for a cation is 1.5×10^{-8} kg/C. What is the mass of this atom ?
(A) 2.4×10^{-19} g (B) 2.4×10^{-27} g (C) 2.4×10^{-24} g (D) None of these

3. An oil drop has 6.39×10^{-19} C charge. Find out the number of electrons in this oil drop.
(A) 2 (B) 4 (C) 6 (D) 8

4. Which of the following statement is true in the context of photoelectic effect ?
(A) The kinetic energy of ejected electron is independent of the intensity of a radiation.
(B) The number of photoelectrons ejected depends upon the intensity of the incident radiation.
(C) The kinetic energy of the emitted electrons depends on the frequency of the incident radiation.
(D) All of these

5. A light source of wavelength λ illuminates a metal and ejects photo-electrons with $(K.E.)_{max} = 1$ eV
Another light source of wavelength $\frac{\lambda}{3}$, ejects photo-electrons from same metal with $(K.E.)_{max} = 4$eV
Find the value of work function ?
(A) 1 eV (B) 2 eV (C) 0.5 eV (D) None of these

6. 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

7. In an atom, two electrons move round the nucleus in circular orbits of radii R and 4R. The ratio of the time taken by them to complete one revolution is: (Consider Bohr model to be valid)
(A) 1 : 4 (B) 4 : 1 (C) 1 : 8 (D) 8 : 1

8. The angular momentum of an electron in a given orbit is J, Its kinetic energy will be :
(A) $\frac{1}{2}\frac{J^2}{mr^2}$ (B) $\frac{Jv}{r}$ (C) $\frac{J^2}{2m}$ (D) $\frac{J^2}{2\pi}$

9. The potential energy of the electron present in the ground state of Be^{3+} ion is represented by:
(A) $+\frac{e^2}{\pi \epsilon_0 r}$ (B) $-\frac{e}{\pi \epsilon_0 r}$ (C) $-\frac{e^2}{\pi \epsilon_0 r^2}$ (D) $-\frac{e^2}{\pi \epsilon_0 r}$

10. The kinetic energy of the electron present in the ground state of Li^{2+} ion is represented by :
(A) $\frac{3e^2}{8\pi \epsilon_0 r}$ (B) $-\frac{3e^2}{8\pi \epsilon_0 r}$ (C) $\frac{3e^2}{4\pi \epsilon_0 r}$ (D) $-\frac{3e^2}{4\pi \epsilon_0 r}$

11. Which transition in Li^{2+} would have the same wavelength as the $2 \rightarrow 4$ transition in He^{+} ion ?
(A) $4 \rightarrow 2$ (B) $2 \rightarrow 4$ (C) $3 \rightarrow 6$ (D) $6 \rightarrow 2$

12. 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) $\upsilon_1 + \upsilon_2 = \upsilon_3$

13. No. of visible lines when an electron returns from 5th orbit upto ground state in H spectrum :
(A) 5 (B) 4 (C) 3 (D) 10

14. If the shortest wave length of Lyman series of H atom is x, then the wave length of the first line of Balmer series of H atom will be -
(A) 9x/5 (B) 36x/5 (C) 5x/9 (D) 5x/36

15. In a sample of H-atoms, electrons de-excite from a level 'n' to 1. The total number of lines belonging to Balmer series are two. If the electrons are ionised from level 'n' by photons of energy 13 eV. Then the kinetic energy of the ejected photoelectrons will be :
(A) 12.15 eV (B) 11.49 eV (C) 12.46 eV (D) 12.63 eV

16. A particle X moving with a certain velocity has a debroglie wave length of 1Å, 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 Å (B) 5.33 Å (C) 6.88 Å (D) 48 Å

17. The ratio of the de-broglie wavelength of a proton and α-particles will be 1 : 2 if their :
(A) velocity are in the ratio 1 : 8. (B) velocity are in the ratio 8 : 1.
(C) kinetic energy are in the ratio 1 : 64. (D) kinetic energy are in the ratio 1 : 256.

18. De Broglie wavelength of an electron after being accelerated by a potential difference of V volt from rest is:
(A) $\lambda = \frac{12.3}{\sqrt{h}}$ Å (B) $\lambda = \frac{12.3}{\sqrt{V}}$ Å (C) $\lambda = \frac{12.3}{\sqrt{E}}$ Å (D) $\lambda = \frac{12.3}{\sqrt{m}}$ Å

19. 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) $\lambda = \sqrt{\frac{h}{m}}$

20. 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) $\frac{h}{4\pi}$

21. 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) $(13.6)\, \lambda$ (D) $n\lambda$

22. Which orbital is non-directional
(A) s (B) p (C) d (D) All

23. In case of $d_{x^2-y^2}$ orbital
(A) Probability of finding the electron along x-axis is zero.
(B) Probability of finding the electron along y-axis is zero.
(C) Probability of finding the electron is maximum along x and y-axis.
(D) Probability of finding the electron is zero in x-y plane

24. In an atomic orbital, the sign of lobes indicates the :
(A) sign of the probability distribution (B) sign of charge
(C) sign of the wave function (D) presence or absence of electron

25. The correct set of four quantum numbers for the valence electron of Rubidium (Z = 37) is :

(A) n = 5, ℓ = 0, m = 0, s = $+\frac{1}{2}$ (B) n = 5, ℓ = 1, m = 0, s = $+\frac{1}{2}$

(C) n = 5, ℓ = 1, m = 1, s = $+\frac{1}{2}$ (D) n = 6, ℓ = 0, m = 0, s = $+\frac{1}{2}$

26. The value of the spin 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+}

27. 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, $\sqrt{20}\hbar$, $\sqrt{6}$

28. 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

29. If n and ℓ are respectively the principal 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) $\sum_{\ell=0}^{\ell=n-1} 2(2\ell+1)$

30. 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.

31. The number of α and β particles lost when ${}^{238}_{92}U$ changes to ${}^{206}_{82}Pb$:
(A) 8α, 6β (B) 6α, 6β (C) 6α, 8β (D) 4α, 4β

PART - II : NUMERICAL VALUE QUESTIONS

1. The ratio of specific charge (e/m) of a proton and that of an α-particle is :

2. Compare the energies of two radiation one with a wavelength of 300 nm and other with 600 nm.

3. The latent heat of fusion of ice is 330 J/g. Calculate the number of photons of radiation of frequency 5×10^{13} s^{-1} to cause the melting of 1 mole of ice. Take h = 6.6×10^{-34} J.S. Express your answer as X × 10^{22}, what is the value of 'X'.

4. The work function for a metal is 40 eV. To emit photo electrons of zero velocity from the surface of the metal the wavelength of incident light should be x nm.

5. Electrons in a sample of H-atoms make transition 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 maximum energy photons has an energy of 0.6375 eV, find the value of x.

[Take 0.6375 eV = $\frac{3}{4}$ × 0.85 eV]

6. If first ionization potential of a hypothetical atom is 16 V, then the first excitation potential will be :

7. In hydrogen atom an orbit has a diameter of about 16.92Å. What is the maximum number of electrons that can be accommodated.

8. Electrons in the H-atoms jump from some higher level upto 3^{rd} energy level. If six spectral lines are possible for the transition, find the initial position of electron.

9. Photon having energy equivalent to the binding energy of 4th state of He^+ atom is used to eject an electron from the metal surface of work function 1.4 eV. If electrons are further accelerated through the potential difference of 4V then the minimum value of De–broglie wavelength associated with the electron is :

10. An electron in Li^{2+} ion makes a transition from higher state n_2 to lower state $n_1 = 6$. The emitted photons is used to ionize an electron in H–atom from 2^{nd} excited state. The electron on leaving the H–atom has a de–Broglie wavelength $\lambda = 12.016$ Å. Find the value of n_2.

Note : Use $(12.016)^2 = \frac{150 \times 144}{13.6 \times 11}$, $\lambda_{Å} = \sqrt{\frac{150}{KE_{eV}}}$.

11. The radial distribution curve of 2s sublevel consists of x nodes, Find out value of x.

12. The wave function of atomic orbital of H like atoms is given as under

$$\psi_{2s} = \frac{1}{4\sqrt{2\pi}} z^{3/2} [2 - Zr]e^{Zr/2}$$

Given that the radius is in Å, then which of the following is radius for nodal surface for He^+ ion ?

13. How many of these orbitals have maximum orbital angular probability distribution is maximum at an angle of 45° to the axial direction.
d_{xy}, $d_{x^2-y^2}$, d_{yz}, d_{xz}, d_{z^2} , P_x, P_y, P_z, s

14. Total number of electrons having $n + \ell = 3$ in Cr (24) atom in its ground state is :

15. An ion Mn^{a+} has the spin magnetic moment equal to 4.9 BM. The value of a is : (atomic no. of Mn = 25)

16. The number of neutrons accompanying the formation of ${}^{139}_{54}Xe$ and ${}^{94}_{38}Sr$ from the absorption of a slow neutron by ${}^{235}_{92}U$ followed by nuclear fission is :

PART - III : ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

1. Isotone of ${}^{76}_{32}Ge$ is/are :
(A) ${}^{77}_{32}Ge$ (B) ${}^{77}_{33}As$ (C) ${}^{77}_{34}Se$ (D) ${}^{78}_{34}Se$

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

3. When alpha particles are sent towards 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

4. From the α-particle scattering experiment, Rutherford concluded that
(A) α-particle can come within a distance of the order of 10^{-14} m from the nucleus
(B) the radius of the nucleus is less than 10^{-14} m
(C) scattering followed Coulomb's law
(D) the positively charged parts of the atom move with extremely high velocities

5. A sodium street light gives off yellow light that has a wavelength of 600 nm. Then
(For energy of a photon take $E = \frac{12400 \text{ eV Å}}{\lambda(Å)}$)
(A) frequency of this light is 7×10^{14} s^{-1}.
(B) frequency of this light is 5×10^{14} s^{-1}.
(C) wave number of the light is 3×10^6 m^{-1}.
(D) energy of the photon is approximately 2.07 eV.

6. The spectrum of He^+ is expected to be similar to that of :
(A) Li^{2+} (B) He (C) H (D) Na

7. Choose the correct relations on the basis of Bohr's theory.
(A) Velocity of electron $\propto \frac{1}{n}$
(B) Frequency of revolution $\propto \frac{1}{n^3}$
(C) Radius of orbit $\propto n^2 Z$
(D) Electrostatic force on electron $\propto \frac{1}{n^4}$

8. 1^{st} excitation potential for the H-like (hypothetical) sample is 24 V. Then :
(A) Ionisation energy of the sample is 36 eV (B) Ionisation energy of the sample is 32 eV
(C) Binding energy of 3^{rd} excited state is 2 eV (D) 2^{nd} excitation potential of the sample is $\frac{32 \times 8}{9}$ V

9. 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) $n = 2 \rightarrow n = 1$

10. In a H-like sample, electrons make transition from 4^{th} excited state upto 2^{nd} state. Then :
(A) 10 different spectral lines are observed
(B) 6 different spectral lines are observed
(C) number of lines belonging to the balmer series is 3
(D) Number of lines belonging to paschen series is 2.

11. The change in angular momentum corresponding to an electron in Balmer transition inside a hydrogen atom can be :
(A) $\frac{h}{4\pi}$ (B) $\frac{h}{\pi}$ (C) $\frac{h}{2\pi}$ (D) $\frac{h}{8\pi}$

12. The qualitative order of Debroglie wavelength for electron, proton and α particle is $\lambda_e > \lambda_P > \lambda_\alpha$ if
(A) If kinetic energy is same for all particles
(B) If the accelerating potential difference **'V'** is same for all the particles (from rest)
(C) If velocities are same for all particles
(D) None of the above

13. Which of the following statements is/are correct for an electron of quantum numbers n = 4 and m = 2 ?
(A) The value of ℓ may be 2. (B) The value of ℓ may be 3.
(C) The value of s may be +1/2. (D) The value of ℓ may be 0, 1, 2, 3.

14. If element $_{25}X^{+Y}$ has spin magnetic moment 1.732 B.M then
(A) number of unpaired electron = 1 (B) number of unpaired electron = 2
(C) Y = 4 (D) Y = 6

15. 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) $S = \pm\frac{1}{2} \times \frac{h}{2\pi}$

16. Which of the following statement(s) is (are) correct?
(A) The electronic configuration of Cr is [Ar] $(3d)^5(4s)^1$. (Atomic number of Cr = 24)
(B) The magnetic quantum number may have negative values.
(C) In silver atom, 23 electrons have a spin of one type and 24 of the opposite type. (Atomic number of Ag = 47)
(D) None of these

17. The configuration [Ar] $3d^{10}\ 4s^2\ 4p^4$ is similar to that of
(A) boron (B) oxygen (C) sulphur (D) aluminium

18. Which consists of charged particles of matter?
(A) α-particle (B) β-particle (C) γ-rays (D) Anode rays

19. Which of the following does not occur ?
(A) ${}^{40}_{20}Ca + {}^{1}_{0}n \rightarrow {}^{40}_{19}K + {}^{1}_{1}H$ (B) ${}^{24}_{12}Mg + {}^{4}_{2}He \rightarrow {}^{27}_{14}Si + {}^{1}_{0}n$
(C) ${}^{113}_{48}Cd + {}^{1}_{0}n \rightarrow {}^{112}_{48}Cd + {}^{0}_{-1}e$ (D) ${}^{43}_{20}Ca + {}^{4}_{2}He \rightarrow {}^{46}_{21}Sc + {}^{1}_{1}H$

20. Pickout the correct statements :
(A) Negative β-decay decreases the proportion of neutrons and increases the proportion of proton.
(B) Positive β-decay increases the proportion of neutrons and decreases the proportion of proton.
(C) K-electron capture increases the proportion of neutrons and increases the proportion of proton.
(D) Positrons and electrons quickly unite to produce photons.

PART - IV : COMPREHENSION

Read the following passage carefully and answer the questions.

Comprehension # 1

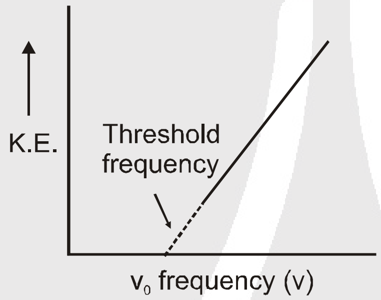
In the photoelectric effect the electrons are emitted instantaneously from a given metal plate, when it is irradiated with radiation of frequency equal to or greater than some minimum frequency, called the threshold frequency. According to planck's idea, light may be considered to be made up of discrete particles called photons. Each photon carries energy equal to hν. When this photon collides with the electron of the metal, the electron acquires energy equal to the energy of the photon. Thus the energy of the emitted electron is given by :

$$h\nu = K.E_{maximum} + P.E. = \frac{1}{2}mu^2 + PE$$

If the incident radiation is of threshold frequency the electron will be emitted without any kinetic energy i.e. $h\nu_0 = PE$

$$\therefore \quad \frac{1}{2}mu^2 = h\nu - h\nu_0$$

A plot of kinetic energy of the emitted electron versus frequency of the incident radiation yields a straight line given as



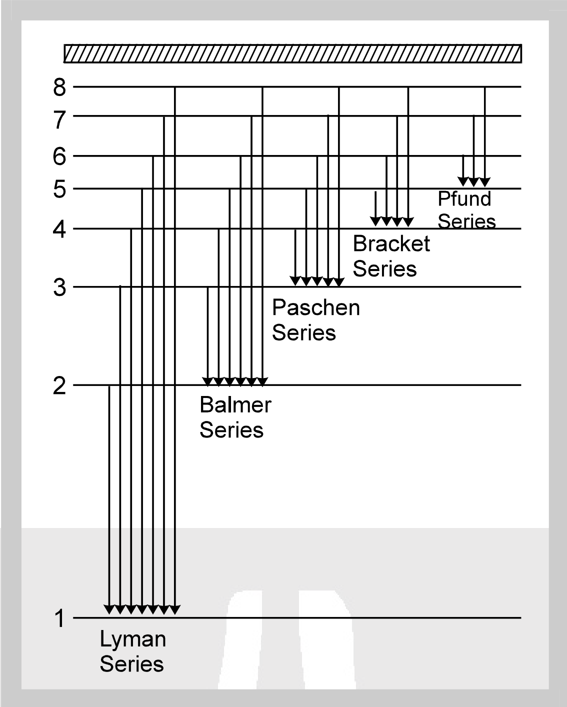
1. A beam of white light is dispersed into its wavelength components by a Quartz prism and falls on a thin sheet of potassium metal. What is the correct decreasing order of maximum kinetic energy of the electron emitted by the different light component?
(A) blue > green > orange > yellow (B) violet > blue > orange > red
(C) yellow > green > blue > violet (D) orange > yellow > blue > violet

2. A laser producing monochromatic light is used to eject electron from the sheet of gold having threshold frequency 6.15 x 10^{14} s^{-1} which of the following incident radiation will be suitable for the ejection of electron:
(A) 1.5 moles of photons having frequency 3.05×10^{14} s^{-1}
(B) 0.5 moles of photon of frequency 12.3×10^{12} s^{-1}
(C) One photon with frequency 5.16×10^{15} s^{-1}
(D) All of the above

3. The number of photoelectrons emitted depends upon :
(A) The intensity of the incident radiation
(B) The frequency of the incident radiation
(C) The product of intensity and frequency of incident radiation
(D) None of these

Comprehension # 2

The only electron in the hydrogen atom resides under ordinary conditions on the first orbit. When energy is supplied, the electron moves to higher energy orbit depending on the amount of energy absorbed. When this electron returns to any of the lower orbits, it emits energy. Lyman series is formed when the electron returns to the lowest orbit while Balmer series is formed when the electron returns to second orbit. Similarly, Paschen, Brackett and Pfund series are formed when electron returns to the third, fourth and fifth orbits from higher energy orbits respectively (as shown in figure)



Maximum number of lines produced when electrons jump from n^{th} level to ground level is equal to $\frac{n(n-1)}{2}$.

For example, in the case of n = 4, number of lines produced is 6. ($4 \to 3$, $4 \to 2$, $4 \to 1$, $3 \to 2$, $3 \to 1$, $2 \to 1$). When an electron returns from n_2 to n_1 state, the number of lines in the spectrum will be equal to

$$\frac{(n_2-n_1)(n_2-n_1+1)}{2}$$

If the electron comes back from energy level having energy E_2 to energy level having energy E_1, then the difference may be expressed in terms of energy of photon as :

$$E_2 - E_1 = \Delta E, \quad \lambda = \frac{hc}{\Delta E}, \qquad \Delta E = h\nu \ \ (\nu \text{ - frequency})$$

Since h and c are constants, ΔE corresponds to definite energy; thus each transition from one energy level to another will produce a light of definite wavelength. This is actually observed as a line in the spectrum of hydrogen atom.

Wave number of line is given by the formula $\bar{\nu} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$.

where R is a Rydberg constant ($R = 1.1 \times 10^7\ m^{-1}$)

(i) First line of a series : It is called 'line of longest wavelength' or 'line of shortest energy'.

(ii) Series limit or last line of a series : It is the line of shortest wavelength or line of highest energy.

4. Last line of Brackett series for H-atom has wavelength λ_1Å and 2^{nd} line of lyman series has wavelength λ_2Å, then :

(A) $\frac{128}{\lambda_1} = \frac{9}{\lambda_2}$ (B) $\frac{16}{\lambda_1} = \frac{9}{\lambda_2}$ (C) $\frac{4}{\lambda_1} = \frac{1}{\lambda_2}$ (D) $\frac{128}{\lambda_1} = \frac{8}{\lambda_2}$

5. Consider the following statements

1. Spectral lines of He^+ ion belonging to Balmer series are not in visible range.
2. In the balmer series of H-atom maximum lines are in ultra violet region.
3. 2^{nd} line of lyman series of He^+ ion has energy 48.4 eV

The above statements 1, 2, 3 respectively are (T = True, F = False)

(A) T F F (B) F T T (C) T F T (D) T T T

6. Wave number of the first line of Paschen series in Be^{3+} ion is

(A) $\frac{7R}{16}$ (B) $\frac{7R}{144}$ (C) $\frac{7R}{9}$ (D) $\frac{R}{144}$

Comprehension # 3

de Broglie proposed dual nature for electron by putting his famous equation $\lambda = \frac{h}{mv}$. Later on Heisenberg proposed uncertainty principle as $\Delta p.\Delta x \geq \frac{h}{4\pi}$. On the contrary, particle nature of electron was established on the basis of photoelectric effect. When a photon strikes the metal surface, it gives up its energy to the electron. Part of this energy (say W) is used by the electrons to escape from the metal and the remaining energy imparts kinetic energy (1/2 mv^2) to the ejected photoelectron. The potential applied on the surface to reduce the velocity of photoelectron to zero is known as stopping potential.

7. Uncertainity in the position of an electron (mass 9.1×10^{-31} kg) moving with a velocity 300 ms^{-1}, accurate upto 0.001% will be : ($\frac{\hbar}{2m_e} = 5.8 \times 10^{-5}$)

(A) 19.2×10^{-2} m (B) 5.76×10^{-2} m (C) 3.84×10^{-2} m (D) 1.92×10^{-2} m

8. When a beam of photons of a particular energy was incident on a surface of a particular pure metal having work function (40 eV), some emitted photoelectrons had stopping potential equal to 22 V, some had 12 V and rest had lower values. Calculate the wavelength of incident photons assuming that at least one photoelectron is ejected with maximum possible kinetic energy.

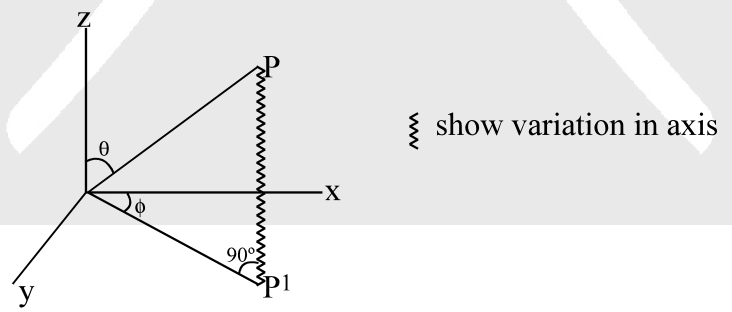
(A) 310 Å (B) 298 Å (C) 238 Å (D) 200 Å

9. The circumference of third orbit of a single electron species is 3 nm. What may be the approximate wavelength of the photon required to just ionize electron from this orbit.

(A) 91.1 nm (B) 364.7 nm (C) 821 nm (D) 205 nm

Comprehension # 4

After the failure of Bohr atomic theory but its ability to explain the atomic spectra a need was felt for the new model that could incorporate, the concept of stationary orbit, de Broglie concept, Heisenberg uncertainty principle. The concept that in corporate above facts is called quantum mechanics of the atomic model wave mechanical model. It includes set of quantum numbers and $|\psi^2|$a mathematical expression of the probability of finding an electron at all points in space.



This probability function is the best indication available of how the electron behaves, for as a consequence of the Uncertainty Principle, the amount we can know about the electron is limited. While quantum mechanics can tell us the exact probability of finding an electron at any two particular points, it does not tell us how the electron moves from one of these points to the other. Thus the idea of an electron orbit is lost; it is replaced with a description of where the electron is most likely to be found. This total picture of the probability of finding an electron at various points in space is called an orbital.

There are various types of orbitals possible, each corresponding to one of the possible combinations of quantum numbers. These orbitals are classified according to the value of n and l associated with them. In order to avoid confusion over the use of two numbers, the numerical values of l are replaced by letters; electrons in orbitals with l = 0 are called s-electrons those occupying orbitals for which l = 1 are p-electrons and those for which l = 2 are called d-electrons. The numerical and alphabetical

correspondences are summarized in table. Using the alphabetical notation for l, we would say that in the ground state of hydrogen atom (n = 1, l = 0) we have a 1s-electron, or that the electron moves in a 1s-orbital. The relation of the spherical polar co-ordinates r, θ and ϕ to Cartesian coordinates x, y and z. To make the concept of an orbital more meaningful, it is helpful to examine the actual solution of the wave function for the one-electron atom. Because of the spherical symmetry of the atom, the wave functions are most simply expressed in terms of a spherical polar-coordinate system, shown in fig., which has its orbit at the nucleus. It is found that the wave functions can be expressed as the product of two functions, one of which (the "angular part" X) depends only the angle θ and ϕ, the other of which (the "radial part" R) depends only on the distance from the nucleus. Thus we have $\psi(r, \theta, \phi) = R(r)\, X(\theta, \phi)$.
Angular and radial parts of hydrogen atom wave functions

Angular part $X(\theta, \phi)$	Radial part $R_{n,\ell}(r)$
$X(s) = \left(\frac{1}{4\pi}\right)^{1/2}$	$R(1s) = 2\left(\frac{z}{a_0}\right)^{3/2} e^{-\sigma/2}$
$X(p_x) = \left(\frac{3}{4\pi}\right)^{1/2} \sin\theta \cos\phi$	$R(2s) = \frac{1}{2\sqrt{2}}\left(\frac{z}{a_0}\right)^{3/2} (2-\sigma)\, e^{-\sigma/2}$
$X(p_y) = \left(\frac{3}{4\pi}\right)^{1/2} \sin\theta \sin\phi$	$R(2p) = \frac{1}{2\sqrt{6}}\left(\frac{z}{a_0}\right)^{3/2} \sigma\, e^{-\sigma/2}$
$X(p_z) = \left(\frac{3}{4\pi}\right)^{1/2} \cos\theta$	
$X(d_{z^2}) = \left(\frac{5}{16\pi}\right)^{1/2} (3\cos^2\theta - 1)$	
$X(d_{xz}) = \left(\frac{15}{4\pi}\right)^{1/2} \sin\theta \cos\theta \cos\phi$	$R(3s) = \frac{1}{9\sqrt{3}}\left(\frac{z}{a_0}\right)^{3/2} (6 - 6\sigma + \sigma^2)\, e^{-\sigma/2}$
$X(d_{yz}) = \left(\frac{15}{4\pi}\right)^{1/2} \sin\theta \cos\theta \sin\phi$	$R(3p) = \frac{1}{9\sqrt{6}}\left(\frac{z}{a_0}\right)^{3/2} (4-\sigma)\, \sigma e^{-\sigma/2}$
$X(d_{x2-y2}) = \left(\frac{15}{4\pi}\right)^{1/2} \sin^2\theta \cos 2\phi$	$R(3d) = \frac{1}{9\sqrt{30}}\left(\frac{z}{a_0}\right)^{3/2} \sigma^2 e^{-\sigma/2}$
$X(d_{xy}) = \left(\frac{15}{4\pi}\right)^{1/2} \sin^2\theta \sin 2\phi$	

$$\sigma = \frac{2Zr}{na_0} \quad ; \quad a_0 = \frac{h^2}{4\pi^2 me^2}$$

This factorization helps us to visualize the wave function, since it allows us to consider the angular and radial dependences separately. It contains the expression for the angular and radial parts of the one electron atom wave function. Note that the angular part of the wave function for an s-orbital it always the same, $(1/4\pi)^{1/2}$, regardless of principal quantum number. It is also true that the angular dependence of the p-orbitals and of the d-orbitals is independent of principle quantum number. Thus all orbitals of a given types (s, p, or d) have the same angular behaviour The table shows, however, that the radial part of the wave function depends both on the principal quantum number n and on the angular momentum quantum number l.
To find the wave function for a particular state, we simply multiply the appropriate angular and radial parts together called normalized wave function.
The probability of finding an electron at a point within an atom is proportional to the square of orbital wave function, i.e., ψ^2 at that point. Thus, ψ^2 is known as probability density and always a positive quantity.
ψ^2 dV (or $\psi^2 . 4\pi r^2 dr$) represents the probability for finding electron in a small volume dV surrounding the nucleus.

10. The electron probability density for 1s-orbital is best represented by the relation

(A) $\frac{1}{2\sqrt{\pi}}\left(\frac{Z}{a_0}\right)^{3/2} \times e^{-\frac{r}{a_0}}$ (B) $\frac{1}{\pi}\left(\frac{Z}{a_0}\right)^{3} \times e^{-\frac{2zr}{a_0}}$

(C) $\frac{1}{\pi}\left(\frac{Z}{a_0}\right)^{3/2} e^{-\frac{r}{a_0}}$ (D) $\frac{2}{\pi}\left(\frac{Z}{a_0}\right)^{3} e^{-\frac{2zr}{a_0}}$

11. The angular wave function of which orbital will not disturb by the variation with azimuthal angle only
(A) 1s and 2s (B) $2p_z$ and $2d_{z^2}$ (C) $2p_x$ and $3d_{z^2}$ (D) $2p_x$ and 2s

Comprehension # 5

Quantum numbers are assigned to get complete information of electrons regarding their energy, angular momentum, spectral lines etc. Four quantum numbers are known i.e. principal quantum numbers which tell the distance of electron from nucleus, energy of electron in a particular shell and its angular momentum. Azimuthal quantum number tells about the subshells in a given shell and of course shape of orbital. Magnetic quantum number deals with study of orientations or degeneracy of a subshell.

Spin quantum number which defines the spin of electron designated as $+\frac{1}{2}$ or $-\frac{1}{2}$ represented by ↑ and ↓ respectively. Electron are filled in orbitals following Aufbau rule. Pauli's exclusion principal and Hund's rule of maximum multiplicity. On the basis of this answer the following questions.

12. Two unpaired electrons present in carbon atom are different with respect to their
(A) Principle quantum number (B) Azimuthal quantum number
(C) Magnetic quantum number (D) Spin quantum number

13. Number of electron having the quantum numbers n = 4, ℓ = 0, s = $-\frac{1}{2}$ in Zn^{+2} ion is/are :
(A) 1 (B) 0 (C) 2 (D) 5

14. Spin angular momentum for unpaired electron in sodium (Atomic No. = 11) is
(A) $\frac{\sqrt{3}}{2}$ (B) 0.866 h/2π (C) $-\frac{\sqrt{3}}{2}\frac{h}{2\pi}$ (D) None of these

Comprehension # 6

15, 16 and 17 by appropriately matching the information given in the three columns of the following table.

Electrons are filled in orbitals following Auf-bau rule, Paulli exclusion principle and Hund's rule of maximum multiplicity.

Column 1	Column 2	Column 3
(I) Cu^{+}	(i) Number of unpaired electrons are 4	(P) Magnetic moment is $\sqrt{15}$ B.M.
(II) Fe^{+3}	(ii) Number of electron related to n + l = 5 are 3	(Q) Number of electrons related to n + ℓ=5 are 6.
(III) Cr^{+3}	(iii) Total spin = $\pm\frac{5}{2}$	(R) Number of electrons to ℓ + m = 0 are 12
(IV) Co^{+3}	(iv) Number of electrons related to ℓ = 2 are 10	(S) Magnetic moment is $\sqrt{35}$ B.M.

15. Ion which have maximum number of full filled orbital then the only correct combination is
(A) (I) (iv) (R) (B) (II) (iii) (P) (C) (III) (i) (S) (D) (IV) (ii) (Q)

16. For the given ion in column I. The only correct combination.
(A) (I) (iv) (S) (B) (II) (i) (R) (C) (III) (ii) (P) (D) (IV) (iii) (Q)

17. For Co^{+3} ion, the only correct combination is
(A) (IV) (ii) (P) (B) (IV) (iii) (S) (C) (IV) (iv) (R) (D) (IV) (i) (Q)

Exercise-3

*** Marked Questions may have more than one correct option.**

PART - I : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

1. The orbit having Bohr radius equal to 1st Bohr orbit of H-atom is : **[JEE 2004, 3/144]**
(A) n = 2 of He^+ (B) n = 2 of B^{+4} (C) n = 3 of Li^{+2} (D) n = 2 of Be^{+3}

2. **(a)** The wave function of an electron in 2s orbital in hydrogen atom is given below :

$$\psi_{2s} = \frac{1}{4(2\pi)^{1/2}}\left(2 - \frac{r}{a_0}\right)\exp(-r/2a_0)$$ **[JEE 2004, 4/60]**

Where a_0 is the Bohr radius. This wave function has a radial node at $r = r_0$. Express r_0 in terms of a_0.
(b) Calculate the wavelength of a ball of mass 100 g moving with a velocity of 100 ms^{-1}.
(c) ${}_{92}X^{238} \xrightarrow[-6\beta]{-8\alpha}$ Y. Find out atomic number, mass number of Y and identify it.

3. (a) Using Bohr's model for hydrogen atom, find the speed of electron in the first orbit if the Bohr's radius is $a_0 = 0.529 \times 10^{-10}$ m. Find deBroglie wavelength of the electron also.
(b) Find the orbital angular momentum of electron if it is in 2p orbital of H in terms of $\frac{h}{2\pi}$.

4. According to Bohr's theory,
E_n = Total energy, K_n = Kinetic energy, V_n = Potential energy, r_n = Radius of nth orbit
Match the following: **[JEE 2006 ,6/184]**

Column I	**Column II**
(A) V_n / K_n = ?	(p) 0
(B) If radius of nth orbit $\propto E_n^x$, x = ?	(q) – 1
(C) Angular momentum in lowest orbital	(r) – 2
(D) $\frac{1}{r_n} \propto Z^y$, y = ?	(s) 1

5. The number of neutrons emitted when ${}^{235}_{92}U$ undergoes controlled nuclear fission to ${}^{142}_{54}Xe$ and ${}^{90}_{38}Sr$ is : **[JEE-2010, 3/163]**

Paragraph for Question Nos. 6 to 8

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.

6. The state S_1 is : **[JEE 2010, 3/163]**
(A) 1s (B) 2s (C) 2p (D) 3s

7. Energy of the state S_1 in units of the hydrogen atom ground state energy is : **[JEE 2010, 3/163]**
(A) 0.75 (B) 1.50 (C) 2.25 (D) 4.50

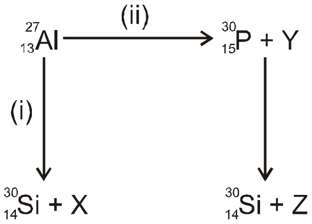
8. The orbital angular momentum quantum number of the state S_2 is : **[JEE 2010, 3/163]**
(A) 0 (B) 1 (C) 2 (D) 3

9. 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, 4/180]**

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

10. The maximum number of electrons that can have principal quantum number, n = 3, and spin quantum number, $m_s = -1/2$, is **[JEE 2011, 4/180]**

11. Bombardment of aluminum by α-particle leads to its artificial disintegration in two ways, (**I**) and (ii) as shown. Products **X**, **Y** and **Z** respectively are, **[JEE 2011, 3/180]**



(A) proton, neutron, positron (B) neutron, positron, proton
(C) proton, positron, neutron (D) positron, proton, neutron

12. The kinetic energy of an electron in the second Bohr orbit of a hydrogen atom is [a_0 is Bohr radius] : **[JEE 2012, 3/136]**

(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) $\frac{h^2}{64\pi^2 m a_0^2}$

13. The periodic table consists of 18 groups. An isotope of copper, on bombardment with protons, undergoes a nuclear reaction yielding element X as shown below. To which group, element X belongs in the periodic table? **[JEE 2012, 4/136]**

$$^{63}_{29}Cu + ^{1}_{1}H \rightarrow 6^{1}_{0}n + ^{4}_{2}\alpha + 2^{1}_{1}H + X$$

14.* In the nuclear transmutation

$$^{9}_{4}Be + X \longrightarrow ^{8}_{4}Be + Y$$

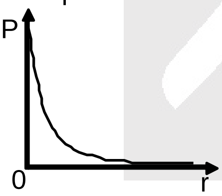
(**X, Y)** is (are) : **[JEE(Advanced) 2013, 3/120]**

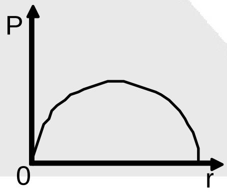
(A) (γ, n) (B) (p, D) (C) (n, D) (D) (γ, p)

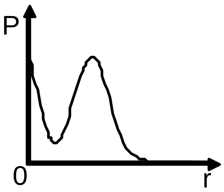
15. In an atom, the total number of electrons having quantum numbers n = 4, $|m_\ell| = 1$ and $m_s = -1/2$ is **[JEE(Advanced) 2014, 3/120]**

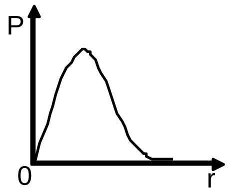
16. Not considering the electronic spin, the degeneracy of the second excited state (n = 3) of H atom is 9, while the degeneracy of the second excited state of H^- is : **[JEE(Advanced) 2015, 4/168]**

17. P is the probability of finding the 1s electron of hydrogen atom in a spherical shell of infinitesimal thickness, dr, at a distance r from the nucleus. The volume of this shell is $4\pi r^2 dr$. The qualitative sketch of the dependence of P on r is: **[JEE(Advanced) 2016, 3/124]**

(A)


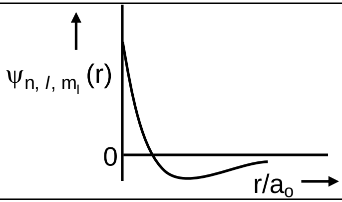
(B)


(C)


(D)


Answer Q.18, Q.19 and Q.20 by appropriately matching the information given in the three columns of the following table.

The wave function, ψ_{n,l,m_l} is a mathematical function whose value depends upon spherical polar coordinates (r, θ, ϕ) of the electron and characterized by the quantum numbers *n*, *l* and m_l. Here r is distance from nucleus, θ is colatitude and ϕ is azimuth. In the mathematical functions given in the Table, Z is atomic number and a_o is Bohr radius.

Column 1	Column 2	Column 3
(I) 1s orbital	(i) $\psi_{n,l,m_l} \propto \left(\frac{Z}{a_o}\right)^{\frac{3}{2}} e^{-\left(\frac{Zr}{a_o}\right)}$	(P) 
(II) 2s orbital	(ii) One radial node	(Q) Probability density at nucleus $\propto \frac{1}{a_o^3}$
(III) $2p_z$ orbital	(iii) $\psi_{n,l,m_l} \propto \left(\frac{Z}{a_o}\right)^{\frac{5}{2}} r e^{-\left(\frac{Zr}{2a_o}\right)} \cos\theta$	(R) Probability density is maximum at nucleus
(IV) $3d_{z^2}$ orbital	(iv) xy-plane is a nodal plane	(S) Energy needed to excite electron from n = 2 state to n = 4 state is $\frac{27}{32}$ times the energy needed to excite electron from n = 2 state to n = 6 state

18. For He^+ ion, the only **INCORRECT** combination is **[JEE(Advanced) 2017, 3/122]**
(A) (I) (i) (S) (B) (II) (ii) (Q) (C) (I) (iii) (R) (D) (I) (i) (R)

19. For the given orbital in Column 1, the only **CORRECT** combination for any hydrogen-like species is **[JEE(Advanced) 2017, 3/122]**
(A) (II) (ii) (P) (B) (I) (ii) (S) (C) (IV) (iv) (R) (D) (III) (iii) (P)

20. For hydrogen atom, the only **CORRECT** combination is **[JEE(Advanced) 2017, 3/122]**
(A) (I) (i) (P) (B) (I) (iv) (R) (C) (II) (i) (Q) (D) (I) (i) (S)

21.* In the decay sequence,

$$^{238}_{92}U \xrightarrow{-x_1} {}^{234}_{90}Th \xrightarrow{-x_2} {}^{234}_{91}Pa \xrightarrow{-x_3} {}^{234}Z \xrightarrow{-x_4} {}^{230}_{90}Th$$

x_1, x_2, x_3 and x_4, are particles/radiation emitted by the respective isotopes. The correct options(s) is(are): **[JEE(Advanced) 2019, 4/124]**

(A) x_1 will deflect towards negatively charged plate. (B) x_2 is β^-
(C) x_3 is γ-ray (D) z is an isotope of uranium

22.* The ground state energy of hydrogen atom is –13.6 eV. Consider an electronic state Ψ of He^+ whose energy, azimuthal quantum number and magnetic quantum number are –3.4 eV, 2 and 0, respectively. Which of the following statement(s) is(are) true for the state Ψ ? **[JEE(Advanced) 2019, 4/124]**
(A) It is a 4d state
(B) The nuclear charge experienced by the electron in this state is less than 2e, where e is the magnitude of the electronic charge
(C) It has 3 radial nodes
(D) It has 2 angular nodes

Answer the following by appropriately matching the lists based on the information given in the paragraph.

Consider the Bohr's model of a one-electron atom where the electron moves around the nucleus. In the following List-I contains some quantities for the n^{th} orbit of the atom and List-II contains options showing how they depend on n.

	List-I		List-II
(I)	Radius of the n^{th} orbit	(P)	$\propto n^{-2}$
(II)	Angular momentum of the electron in the n^{th} orbit	(Q)	$\propto n^{-1}$
(III)	Kinetic energy of the electron in the n^{th} orbit	(R)	$\propto n^{0}$
(IV)	Potential energy of the electron in the n^{th} orbit	(S)	$\propto n^{1}$
		(T)	$\propto n^{2}$
		(U)	$\propto n^{1/2}$

23. Which of the following has the correct combination considering List-I and List-II ? **[JEE(Advanced) 2019, 3/124]**

(A) (III), (S) (B) (IV), (Q) (C) (III), (P) (D) (IV), (U)

24. Which of the following options has the correct combination considering List-I and List-II ? **[JEE(Advanced) 2019, 3/124]**

(A) (II), (R) (B) (II), (Q) (C) (I), (P) (D) (I), (T)

PART - II : JEE (MAIN) ONLINE PROBLEMS (PREVIOUS YEARS)

1. The energy of an electron in first Bohr orbit of H-atom is –13.6 eV. The energy value of electron in the excited state of Li^{2+} is : **[JEE(Main) 2014 Online (09-04-14), 4/120]**

(1) – 27.2 eV (2) 30.6 eV (3) – 30.6 eV (4) 27.2 eV

2. If λ_0 and λ be the threshold wavelength and wavelength of incident light, the velocity of photoelectron ejected from the metal surface is : **[JEE(Main) 2014 Online (11-04-14), 4/120]**

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

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

3. Based on the equation: $\Delta E = 2.0 \times 10^{-18}\ J\left(\frac{1}{n_2^2} - \frac{1}{n_1^2}\right)$

the wavelength of the light that must be absorbed to excite hydrogen electron from level n = 1 to level n = 2 will be : ($h = 6.625 \times 10^{-34}$ Js, $C = 3 \times 10^{8}\ ms^{-1}$) **[JEE(Main) 2014 Online (09-04-14), 4/120]**

(1) 1.325×10^{-7} m (2) 1.325×10^{-10} m (3) 2.650×10^{-7} m (4) 5.300×10^{-10} m

4. If m and e are the mass and charge of the revolving electron in the orbit of radius r for hydrogen atom, the total energy of the revolving electron will be : **[JEE(Main) 2014 Online (12-04-14), 4/120]**

(1) $\frac{1}{2}\frac{e^2}{r}$ (2) $-\frac{e^2}{r}$ (3) $\frac{me^2}{r}$ (4) $-\frac{1}{2}\frac{e^2}{r}$

5. The de-Broglie wavelength of a particle of mass 6.63 g moving with a velocity of 100 ms^{-1} is : **[JEE(Main) 2014 Online (12-04-14), 4/120]**

(1) 10^{-33} m (2) 10^{-35} m (3) 10^{-31} m (4) 10^{-25} m

6. Excited hydrogen atom emits light in the ultraviolet region at 2.47×10^{15} Hz With thi frequency, the energy of a single photon is : ($h = 6.63 \times 10^{-34}$ Js) **[JEE(Main) 2014 Online (12-04-14), 4/120]**

(1) 8.041×10^{-40} J (2) 8.041×10^{-19} J (3) 1.640×10^{-18} J (4) 6.111×10^{-17} J

7. Ionization energy of gaseous Na atom is 495.5 kJ mol^{-1}. The lowest possible frequency of light that ionizes a sodium atom is (h = 6.626×10^{-34} Js, $N_A = 6.022 \times 10^{23}$ mol^{-1})
[JEE(Main) 2014 Online (19-04-14), 4/120]
(1) 7.50×10^4 s^{-1} (2) 4.76×10^{14} s^{-1} (3) 3.15×10^{15} s^{-1} (4) 1.24×10^{15} s^{-1}

8. If the principal quantum number n = 6, the correct sequence of filling of electrons will be :
[JEE(Main) 2015 Online (10-04-15), 4/120]
(1) ns→np→(n – 1)d→(n – 2)f (2) ns→(n – 1)d→(n – 2)f→np
(3) ns→(n – 2)f→np→(n – 1)d (4) ns→(n – 2)f→(n – 1)d→np

9. At temperatuere T, the average kinetic energy of any particle is $\frac{3}{2}$KT. The de Broglie wavelength follows the order : **[JEE(Main) 2015 Online (11-04-15), 4/120]**
(1) Visible photon > Thermal neutron > Thermal electron
(2) Thermal proton > Thermal electon > Visible photon
(3) Thermal proton > Visible photon > Thermal electron
(4) Visible photon > Thermal electron > Thermal neutron

10. The total number of orbitals associated with the principal quantum number 5 is:
[JEE(Main) 2016 Online (09-04-16), 4/120]
(1) 5 (2) 20 (3) 25 (4) 10

11. Aqueous solution of which salt will not contain ions with the electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^6$?
[JEE(Main) 2016 Online (10-04-16), 4/120]
(1) NaCl (2) CaI_2 (3) NaF (4) KBr

12. If the shortest wavelength in Lyman series of hydrogen atom is A, then the longest wavelength in Paschen series of He^+ is : **[JEE(Main) 2017 Online (08-04-17), 4/120]**
(1) $\frac{36A}{5}$ (2) $\frac{9A}{5}$ (3) $\frac{5A}{9}$ (4) $\frac{36A}{7}$

13. The electron in the hydrogen atom undergoes transition from higher orbitals to orbitals of radius 211.6 pm. This transition is associated with : **[JEE(Main) 2017 Online (09-04-17), 4/120]**
(1) Paschen series (2) Brackett series (3) Lyman series (4) Balmer series

14. Ejection of the photoelectron from metal in the photoelectric effect experiment can by stopped by applying 0.5 V when the radiation of 250 nm is used. The work function of the metal is :
[JEE(Main) 2018 Online (15-04-18), 4/120]
(1) 4 eV (2) 5.5 eV (3) 4.5 eV (4) 5 eV

15. The de-Broglie's wavelength of electron present in first Bohr orbit of 'H' atom is :
[JEE(Main) 2018 Online (15-04-18), 4/120]
(1) 0.529 Å (2) $2\pi \times 0.529$ Å (3) $\frac{0.529}{2\pi}$ Å (4) 4×0.529 Å

16. Which of the following statements is **false** ? **[JEE(Main) 2018 Online (16-04-18), 4/120]**
(1) Splitting of spectral lines in electrical field is called Stark effect.
(2) Frequency of emitted radiation from a black body goes from a lower wavelength of higher wavelength as the temperature increases.
(3) Photon has momentum as well as wavelength.
(4) Rydberg constant has unit of energy.

17. For emission line of atomic hydrogen from $n_i = 8$ to $n_f = n$, the plot of wave number $(\bar{\nu})$ against $\left(\frac{1}{n^2}\right)$ will be (The Rydberg constant, R_H is in wave number unit) **[JEE(Main) 2019 Online (09-01-19)S1, 4/120]**
(1) Linear with intercept $-R_H$ (2) Linear with slope $-R_H$
(3) Non linear (4) Linear with slope R_H

18. Which of the following combination of statements is true regarding the interpretation of the atomic orbitals? **[JEE(Main) 2019 Online (09-01-19) S2, 4/120]**

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

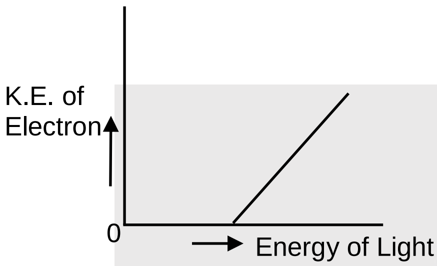
(b) For a given value of the principal quantum number, the size of the orbit is inversely proportional to the azimuthal quantum number.

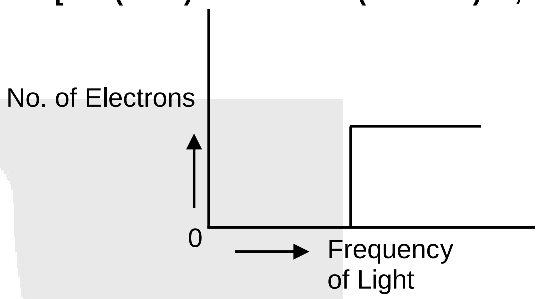
(c) According to wave mechanics, the ground state angular momentum is equal to $\frac{h}{2\pi}$.

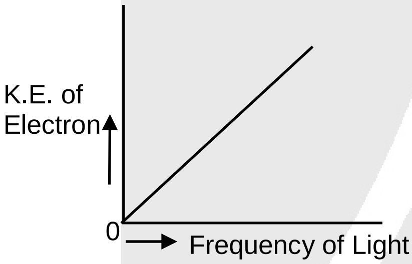
(d) The plot of Ψ Vs r for various azimuthal quantum numbers, show peak shifting towards higher value.

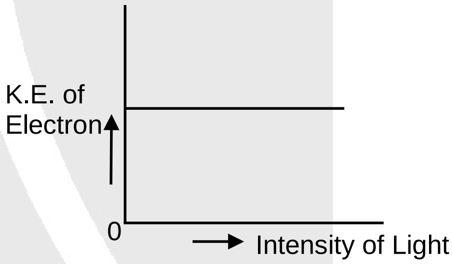
(1) (b), (c) (2) (a), (c) (3) (a), (d) (4) (a), (b)

19. Which of the graphs shown below does not represent the relationship between incident light and the electron ejected from metal surface ? **[JEE(Main) 2019 Online (10-01-19)S1, 4/120]**

(1)


(2)


(3)


(4)


20. The ground state energy of hydrogen atom is –13.6 eV. The energy of second excited state of He^+ ion eV is: **[JEE(Main) 2019 Online (10-01-19)S2, 4/120]**

(1) –27.2 (2) –54.4 (3) –3.4 (4) –6.04

21. Heat treatment of muscular pain involves radiation of wavelength of about 900 nm. Which spectral line of H-atom is suitable for this purpose ? [$R_H = 1 \times 10^5$ cm^{-1}, h = 6.6 × 10^{-34} Js, c = 3 × 10^8 ms^{-1}] **[JEE(Main) 2019 Online (11-01-19)S1, 4/120]**

(1) Paschen, $\infty \to 3$ (2) Paschen, $5 \to 3$ (3) Balmer, $\infty \to 2$ (4) Lyman, $\infty \to 1$

22. The de Broglie wavelength (λ) associated with a photoelectron varies with the frequency (ν) of the incident radiation as, [ν_0 is threshold frequency] : **[JEE(Main) 2019 Online (11-01-19)S1, 4/120]**

(1) $\lambda \propto \frac{1}{(\nu - \nu_0)^{\frac{3}{2}}}$ (2) $\lambda \propto \frac{1}{(\nu_0 - \nu_0)}$ (3) $\lambda \propto \frac{1}{(\nu - \nu_0)^{\frac{1}{2}}}$ (4) $\lambda \propto \frac{1}{(\nu - \nu_0)^{\frac{1}{4}}}$

23. What is the work function of the metal if the light of wavelength 4000Å generates photoelectrons of velocity 6×10^5 ms^{-1} from it ?
(Mass of electron = 9 × 10^{-31} kg, Velocity of light = 3×10^8 ms^{-1}, Plank's constant = 6.626 ×10^{-34} Js, Charge of electron = 1.6 ×10^{-19} JeV^{-1}) **[JEE(Main) 2019 Online (12-01-19)S1, 4/120]**

(1) 3.1 eV (2) 0.9 eV (3) 4.0 eV (4) 2.1 eV

24. If the de Broglie wavelength of the electron in n^{th} Bohr orbit in a hydrogenic atom is equal to 1.5 πa_0 (a_0 is Bohr radius), then the value of n/z is: **[JEE(Main) 2019 Online (12-01-19)S2, 4/120]**

(1) 0.75 (2) 0.40 (3) 1.0 (4) 1. 50

25. The quantum number of four electrons are given below :

(I) $n = 4, \ell = 2, m_\ell = -2, m_s = -1/2$ (II) $n = 3, \ell = 2, m_\ell = 1, m_s = +1/2$

(III) $n = 4, \ell = 1, m_\ell = 0, m_s = +1/2$ (IV) $n = 3, \ell = 1, m_\ell = 1, m_s = -1/2$

The correct order of their increasing energies will be: **[JEE(Main) 2019 Online (08-04-19)S1, 4/120]**

(1) I < II < III < IV (2) I < III < II < IV (3) IV < II < III < I (4) IV < III < II < I

26. If p is the momentum of the fastest electron ejected from a metal surface after the irradiation of light having wavelength λ, then for 1.5 p momentum of the photoelectron, the wavelength of the light should be : **[JEE(Main) 2019 Online (08-04-19)S2, 4/120]**

(Assume kinetic energy of ejected photoelectron to be very high in comparison to work function) :

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

27. For any given series of spectral lines of atomic hydrogen, let $\Delta v = \bar{v}_{max} - \bar{v}_{min}$ be the differenece in maximum and minimum frequencies in cm^{-1}. The ratio $\Delta\bar{v}_{Lyman} / \Delta\bar{v}_{Balmer}$ is :

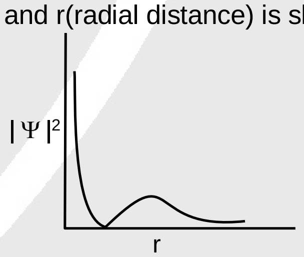
[JEE(Main) 2019 Online (09-04-19)S1, 4/120]

(1) 9 : 4 (2) 5 : 4 (3) 27 : 5 (4) 4 : 1

28. Which one of the following about an electron occupying the 1s orbital in a hydrogen atom is incorrect? (The Bohr radius is represented by a_0). **[JEE(Main) 2019 Online (09-04-19)S2, 4/120]**

(1) The total energy of the electron is maximum when it is at a distance a_0 from the nucleus.
(2) The magnitude of the potential energy is double that of its kinetic energy on an average.
(3) The probability density of finding the electron is maximum at the nucleus.
(4) The electron can be found at a distance $2a_0$ from the nucleus.

29. The graph between $|\Psi|^2$ and r(radial distance) is shown below. This represents:



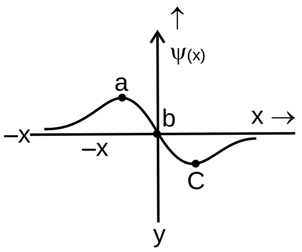
[JEE(Main) 2019 Online (10-04-19)S1, 4/120]

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

30. The ratio of the shortest wavelength of two spectral series of hydrogen spectrum is found to be about 9. The spectral series are : **[JEE(Main) 2019 Online (10-04-19)S2, 4/120]**

(1) Paschen and Pfund (2) Brackett and Pfund
(3) Lyman and Paschen (4) Balmer and Brackett

31. The electrons are more likely to be found : **[JEE(Main) 2019 Online (12-04-19)S1, 4/120]**



(1) only in the region a (2) only in the region c
(3) in region a and c (4) in the region a and b

32. Among the following the energy of 2s orbital is lowest in: **[JEE(Main) 2019 Online (12-04-19)S2, 4/120]**
(1) Na (2) Li (3) H (4) K

33. The number of oribtals associated with quantum number n = 5, $m_s = +\frac{1}{2}$ is:
[JEE(Main) 2020 Online (07-01-20)S1, 4/120]
(1) 11 (2) 25 (3) 50 (4) 15

34. For the Balmer series in the spectrum of H atom, $\bar{\nu} = R_H\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$, the correct statements among (I) to (IV) are : **[JEE(Main) 2020 Online (08-01-20)S1, 4/120]**
(I) As wavelength decreases, the lines in the series converge
(II) The integer n_1 is equal to 2
(III) The lines of longest wavelength corresponds to $n_2 = 3$
(IV) The ionization energy of hydrogen can be calculated from wave number of these lines
(1) (I), (III), (IV) (2) (I), (II), (IV) (3) (II), (III), (IV) (4) (I), (II), (III)

35. Hydrogen has three isotopes (A), (B) and (C). If the number of neutron(s) in (A), (B) and (C) respectively, are (x), (y) and (z) the sum of (x), (y) and (z) is :
[JEE(Main) 2020 Online (08-01-20)S2, 4/120]
(1) 4 (2) 2 (3) 3 (4) 1

36. The radius of the second Bohr orbit, in terms of the Bohr radius, a_0, in Li^{2+} is :
[JEE(Main) 2020 Online (08-01-20)S1, 4/120]
(1) $\frac{2a_0}{3}$ (2) $\frac{4a_0}{9}$ (3) $\frac{4a_0}{3}$ (4) $\frac{2a_0}{9}$

37. The de Broglie wavelength of an electron in the 4th Bohr orbit is :
[JEE(Main) 2020 Online (09-01-20)S1, 4/120]
(1) $4\pi a_0$ (2) $2\pi a_0$ (3) $6\pi a_0$ (4) $8\pi a_0$

Answers

EXERCISE - 1

PART - I

A-1.

Particle	Atomic No.	Mass No.	No. of electrons	No. of protons	No. of neutrons
Sodium atom	11	23	11	11	12
Aluminium ion	13	27	10	13	14
Chloride ion	17	35	18	17	18
Phosphorus atom	15	31	15	15	16
Cuprous ion	29	64	28	29	35

A-2. 1.8×10^{-43} m^3 **A-3.** 2.7×10^{-14} **A-4.** (A) 6.5×10^{-15} m , (B) $\frac{188\ Ke^2}{m_\alpha v^2}$

A-5. 1. Most of the α-particles passed straight through the gold foil undeflected.
2. A few of them were deflected through small angles, while a very few were deflected to a large extent.
3. A very small percentage (1 in 20000) was deflected through angles ranging from nearly 180°.

B-1. 621.1 eV. **B-2.** 1.56×10^{16} **B-3.** 219.3 m, 4.56×10^{-3} m^{-1}

B-4. 239.4 KJ/mol. **B-5.** 1.35×10^5 photons **B-6.** 200 watt.

B-7. 1×10^{16} Hz **C-1.** n = 2 **C-2.** 7.27×10^5 m/s

C-3. x = 2 **C-4.** $\frac{9}{32}$ **C-5.** 'x' **C-6.** A = 2, B = 4

C-7. (a) Z = 3, (b) 108.8 eV, (c) 1.013×10^{-8} m , (d) 122.4 eV **C-8.** 54.4 eV

D-1. 6561 Å, 4863 Å (Approx) **D-2.** n = 4 to n = 2

D-3. $v = 7.3 \times 10^{14}$ Hz, visible spectrum **D-4.** z = 2 **D-5.** 20

E-1. 4.71 Å **E-2.** $v_e = 1836\ v_p$ **E-3.** $\frac{20}{63}$ **E-4.** 6.15 Å

E-5. ≈ 100 gm **F-1.** a = 4 ; b = 2 ; c = 3 ; d = 1

F-2. (i) 4s , 4P , 4d , 4f
(ii) No, it will only be in one of them.
(iii) No. For the hydrogen atom, all orbitals with the same principal quantum number have the same energy (they are degenerate).

G-1. 2 **G-2.** $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^6\ 6s^2$.

G-3. 3p, 5d, 4p, 2s, 4d **G-4.** (a) 0, (b) $\frac{h}{\sqrt{2}\pi}$, (c) $\frac{2h}{\pi}$

G-5. Impossible sets of quantum numbers are (i), (iii), and (vi)

G-6. (i) + 5/2 or – 5/2, spin magnetic moment = $\sqrt{35}$ B.M. (ii) 0, 0

H-1. $\Delta m = 3.07 \times 10^{-26}$ g

H-2. $^{24}_{12}Mg + ^{1}_{0}n \longrightarrow ^{24}_{11}Na + ^{1}_{1}H$

H-3. (a) $^{14}_{7}N + ^{1}_{0}n \longrightarrow ^{14}_{6}C + ^{1}_{1}H$

(b) $^{39}_{19}K + ^{1}_{0}n \longrightarrow ^{36}_{17}Cl + ^{4}_{2}He$

H-4. (a) $^{38}_{20}Ca$: It has $\frac{n}{p} = \frac{18}{20}$ = 0.9, Which lies below the belt of stability and thus positron emitter.

$$^{38}_{20}Ca \longrightarrow ^{38}_{19}K + ^{0}_{+1}e$$

(b) $^{35}_{18}Ar$: It has $\frac{n}{p} = \frac{17}{18}$ = 0.994, which lies below the belt of stability and thus, positron emitter

$$^{35}_{18}Ar \longrightarrow ^{35}_{17}Cl + ^{0}_{+1}e$$

If $\frac{n}{p}$ < 1 and nuclear charge is high the nuclide may show K-electron capture.

(c) $^{80}_{32}Ge$: It has $\frac{n}{p} = \frac{48}{32}$ = 1.5, which lies above the belt of stability and thus β-emitter.

$$^{80}_{32}Ge \longrightarrow ^{80}_{33}As + ^{0}_{-1}e$$

(d) $^{40}_{20}Ca$: It has both magic numbers p = 20, n = 20 and thus, stable.

H-5. 3^n, $3^{n-1}E$

PART - II

A-1.	(A)	**A-2.**	(A)	**A-3.**	(D)	**A-4.**	(B)	**A-5.**	(A)
A-6.	(C)	**B-1.**	(A)	**B-2.**	(C)	**B-3.**	(A)	**B-4.**	(D)
B-5.	(C)	**B-6.**	(D)	**C-1.**	(A)	**C-2.**	(B)	**C-3.**	(B)
C-4.	(A)	**C-5.**	(A)	**C-6.**	(C)	**C-7.**	(B)	**D-1.**	(A)
D-2.	(D)	**D-3.**	(C)	**D-4.**	(B)	**D-5.**	(C)	**D-6.**	(D)
D-7.	(D)	**E-1.**	(C)	**E-2.**	(D)	**E-3.**	(B)	**E-4.**	(C)
E-5.	(B)	**E-6.**	(A)	**E-7.**	(C)	**F-1.**	(C)	**F-2.**	(A)
F-3.	(D)	**F-4.**	(C)	**F-5.**	(C)	**F-6.**	(C)	**F-7.**	(C)
F-8.	(D)	**F-9.**	(D)	**F-10.**	(B)	**G-1.**	(A)	**G-2.**	(D)
G-3.	(A)	**G-4.**	(B)	**G-5.**	(D)	**G-6.**	(A)	**G-7.**	(B)
G-8.	(B)	**G-9.**	(D)	**G-10.**	(C)	**H-1.**	(A)	**H-2.**	(C)
H-3.	(A)	**H-4.**	(B)	**H-5.**	(B)	**H-6.**	(D)		

PART - III

1. (i – f) ; (ii – d) ; (iii – a) ; (iv – e) ; (v – b) ; (vi – c)

2. (i – q) , (ii – p), (iii – q, r) , (iv – r, s).

3. (i – t) ; (ii – s) ; (iii – u) ; (iv – q) ; (v – p) ; (vi – r)

4. (A – s) ; (B – p) ; (C – r) ; (D – q)

EXERCISE - 2

PART - I

1.	(C)	**2.**	(C)	**3.**	(B)	**4.**	(D)	**5.**	(C)
6.	(D)	**7.**	(C)	**8.**	(A)	**9.**	(D)	**10.**	(A)
11.	(C)	**12.**	(A)	**13.**	(C)	**14.**	(B)	**15.**	(A)
16.	(B)	**17.**	(B)	**18.**	(B)	**19.**	(D)	**20.**	(C)
21.	(D)	**22.**	(A)	**23.**	(C)	**24.**	(C)	**25.**	(A)
26.	(B)	**27.**	(A)	**28.**	(A)	**29.**	(D)	**30.**	(D)
31.	(A)								

PART - II

1.	2	**2.**	2	**3.**	18	**4.**	31 nm	**5.**	8
6.	12	**7.**	32	**8.**	6	**9.**	5 Å	**10.**	12
11.	1	**12.**	1Å	**13.**	3	**14.**	8	**15.**	+3
16.	3								

PART - III

1.	(BD)	**2.**	(AB)	**3.**	(AC)	**4.**	(ABC)	**5.**	(BD)
6.	(AC)	**7.**	(ABD)	**8.**	(BCD)	**9.**	(ABCD)	**10.**	(BCD)
11.	(BC)	**12.**	(ABC)	**13.**	(ABC)	**14.**	(AD)	**15.**	(AC)
16.	(ABC)	**17.**	(BC)	**18.**	(ABD)	**19.**	(C)	**20.**	(ABD)

PART - IV

1.	(B)	**2.**	(C)	**3.**	(A)	**4.**	(A)	**5.**	(D)
6.	(C)	**7.**	(D)	**8.**	(D)	**9.**	(C)	**10.**	(B)
11.	(A)	**12.**	(C)	**13.**	(B)	**14.**	(B)	**15.**	(A)
16.	(C)	**17.**	(D)						

EXERCISE - 3

PART - I

1. (D)

2. (a) $r = 2a_0$ (b) $\lambda = 6.626 \times 10^{-25}$ Å
(c) $_{82}Y^{206}$; (Atomic no. 82, Mass no. 206)

3. (a) 2.18×10^6 m/s, 3.32×10^{-10} m (b) $\sqrt{2}\,.\left(\frac{h}{2\pi}\right)$

4. [A — r] ; [B – q] ; [C – p] ; [D – s].

5.	4	**6.**	(B)	**7.**	(C)	**8.**	(B)	**9.**	4
10.	9	**11.**	(A)	**12.**	(C)	**13.**	8	**14.**	(A) (B)
15.	6	**16.**	3	**17.**	(D)	**18.**	(C)	**19.**	(A)
20.	(D)	**21.***	(ABD)	**22.**	(AD)	**23.**	(C)	**24.**	(D)

PART - II

1.	(3)	**2.**	(3)	**3.**	(1)	**4.**	(4)	**5.**	(1)
6.	(3)	**7.**	(4)	**8.**	(4)	**9.**	(4)	**10.**	(3)
11.	(3)	**12.**	(4)	**13.**	(4)	**14.**	(3)	**15.**	(2)
16.	(2)	**17.**	**Answer by NTA (2), answer by Resonance (4).**						
18.	**Answer by NTA (3), answer by Resonance (2).**					**19.**	(3)	**20.**	(4)
21.	(1)	**22.**	(3)	**23.**	(4)	**24.**	(1)	**25.**	(3)
26.	(3)	**27.**	(1)	**28.**	(1)	**29.**	(4)	**30.**	(3)
31.	(3)	**32.**	(4)	**33.**	(2)	**34.**	(4)	**35.**	(3)
36.	(3)	**37.**	(4) $8\pi a_0$						