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STRUCTURE OF ATOM -2 (Test)

Bohr's Model, Hydrogen Spectrum, Photoelectric effect

READ THE INSTRUCTIONS CAREFULLY

1. The test is of **2 hours** duration.
2. The maximum marks are **175**.
3. This test consists of **55** questions.
4. For each question in **Section A, B, C & D** you will be **awarded 3 marks** if you have darkened only the bubble corresponding to the correct answer and **zero mark** if no bubbles are darkened. **Minus one (-1) mark** will be awarded for wrong answer.
5. For each question in **Section–E (Matrix Match),** you will be **awarded 2 marks** for each row in which you have darkened the bubble(s) corresponding to the correct answer. Thus, each question in this section carries a maximum of **8 marks.** There is **no negative marks awarded** for incorrect answer(s) in this Section.
6. For each question in **Section–F (Integer Type),** you will be **awarded 3 marks** if you darken the bubble corresponding to the correct answer and **zero mark** if no bubble is darkened. **No negative marks** will be awarded for in this Section.
7. Keep Your **mobiles switched off** during Test in the Halls.

SECTION – A (Single Correct Choice Type)

This Section contains **29 multiple choice questions.** Each question has four choices A), B), C) and D) out of which **ONLY ONE** is correct. (Mark only One choice) **29 × 3 = 87 Marks**

1. Wavelength of high energy transition of H atoms is 91.2 nm. Calculate the corresponding wavelength of He^+.

a. 22.8 nm b. 44.4 nm c. 11.4 nm d. 45.6 nm

A

Sol. For H atom $\bar{\upsilon}_H = R_H\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)$ -------- (1)

For He^+ ion $\bar{\upsilon}_{He^+} = R_H.Z^2\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)$ -------- (2)

From eqs. (1) and (2) we have

$\frac{\bar{\upsilon}_{He^+}}{\bar{\upsilon}_H} = Z^2 = (2)^2 = 4$ (For He^+, Z = 2) Or $\frac{\lambda_H}{\lambda_{He^+}} = 4$ Or $\lambda_{He^+} = \frac{\lambda_H}{4} = \frac{91.2}{4}$

= 22.8 nm.

2. The threshold frequency of a certain metal is 3.3×10^{14} Hz. If light of frequency 8.2×10^{14} Hz is incident on the metal, find the cut off voltage for photo electric emission. Given $h = 6.62 \times 10^{-34}$ Js

a. 4.04 V b. 2.02 V c. 20.2 V d. 0.202 V

B

Sol. Here, $\upsilon_0 = 3.3 \times 10^{14}$ Hz

$\upsilon = 8.2 \times 10^{14}$ Hz

$h = 6.62 \times 10^{-34}$ Js.

Using $eV_0 = h(\upsilon - \upsilon_0)$, we get

$$V_0 = \frac{h}{e}(\upsilon - \upsilon_0)$$

$$= \frac{6.62 \times 10^{-34}}{1.6 \times 10^{-19}} (8.2 \times 10^{14} - 3.3 \times 10^{14})$$

$$= 2.02 \text{ V}$$

3. An electron in Bohr's H-atom has an energy of -3.4 eV. What is the angular momentum of the electron?

a. 2.11×10^{-34} Js b. 3.89×10^{-34} Js c. 4.22×10^{-34} Js d. 1.05×10^{-34} Js

A

Sol. The energy of an electron in H-atom in an orbit n is given as

$$E = \frac{-13.6}{n^2} eV$$

$$\therefore \quad -3.4 \text{ eV} = \frac{-13.6}{n^2} eV$$

$$\therefore \quad n = 2$$

The angular momentum of an electron in nth orbit is given as

$$m\nu r = \frac{nh}{2\pi} = \frac{2 \times 6.63 \times 10^{-34}}{2 \times 3.14} = 2.11 \times 10^{-34} \text{ Js}$$

4. The ionisation energy of He^+ is 19.6×10^{-18} J $atom^{-1}$.Calcuate ionisation energy of Li^{++} ion.

a. 44.1×10^{-18} J atom b. 4.41×10^{-18} J atom
c. 2.41×10^{-18} J atom d. 34.1×10^{-18} J atom

A

Sol. Energy of first orbit of Li^+

$$\left(E_{He^+}\right)_1 = - Z^2 \text{ He} \quad \text{(constant)}$$

$$E_{Li^{+2}} = - Z^2 \text{ Li} \quad \text{(constant)}$$

$$\left(E_{Li^{+2}}\right)_1 = \frac{Z^2 \text{ Li}}{Z^2 \text{ He}} \left(E_{He^+}\right)_1$$

$$= \frac{3^2}{2^2}(19.6 \times 10^{-18} \text{ J atom}^{-1})$$

$$= 44.1 \times 10^{-18} \text{ J atom}^{-1}$$

5. Photoelectric effect shows:

a. Particle-like behaviour of light
b. Wave-like behaviour of light
c. Both wave-like and particle-like behaviour of light
d. Neither wave-like nor particle-like behaviour of light

A

Sol. It is an experimental evidence for particle nature of electron

6. The radius of H-atom in ground state is 0.53 Å. Radius of first orbit of Li^{2+} in Å is:

a. 0.106 b. 0.3 c. 0.176 d. 0.52

C

Sol. $r_{1\ Li^{2+}} = \frac{r_1 H}{Z} = \frac{0.53}{3} = 0.176$ Å

7. Of the following which of the statement(s) regarding Bohr theory is wrong:

a. Kinetic energy of an electron is half of the magnitude of its potential energy
b. Kinetic energy of an electron is negative of total energy of electron
c. Energy of electron decreases with increase in the value of the principle quantum number
d. The ionization energy of H-atom in the first excited state is negative of one fourth of the energy of an electron in the ground state

C

Sol. Energy of electron increases with increase in n $\left[E_n \alpha -\frac{1}{n^2}\right]$

8. The ratio of the difference in energy of electron between the first and second Bohr's orbits to that between second and third Bohr's orbits is:

a. 1/3 b. 27/5 c. 9/4 d. 4/9

B

Sol. $E_n = \frac{E_1}{n^2}$, Find $\frac{(E_2 - E_1)}{(E_3 - E_2)} = \frac{3/4}{5/36}$

9. The electronic velocity in the fourth Bohr's orbit of hydrogen is u. The velocity of the electron in the first orbit would be:

a. 4u b. 16u c. u/4 d. u/16

A

Sol. $u_n = \frac{u_1}{n}$

10. How much energy should be absorbed by a hydrogen atom in ground state to reach first excited state?

a. +1.5 eV b. 3.4 eV c. 13.4 eV d. 10.2 eV

D

Sol. For the electron to go to second orbit,

$$\Delta E = E_2 - E_1 = -3.4 - (-13.6)$$
$$= 13.6 - 3.4 = 10.2 \text{ eV}$$

11. The distance between 3rd and 2nd orbits in the hydrogen atom is

a. 2.116×10^{-8} cm b. 2.646×10^{-8} cm
c. 0.529×10^{-8} cm d. 1.058×10^{-8} cm

B

Sol. $r_3 = 0.529$ Å $\times 3^2 = 4.761$ Å
$r_2 = 0.529$ Å $\times 2^2 = 2.116$ Å

$$\left(\because r_n = 0.529\text{Å}.Z^2\right)$$

$r_3 - r_2 = 4.761 - 2.116$ Å $= 2.645$ Å

12. Velocity of electron in the second orbit of H-atom as compared to that of light is nearly

a. $\frac{1}{10}$ b. $\frac{1}{100}$ c. $\frac{1}{274}$ d. $\frac{1}{548}$

C

Sol. $\frac{V_{light}}{V_{electron}} = 137 \times \frac{n}{Z}$

$\frac{V_\ell}{V_e} = 137 \times 2$ or $\frac{V_e}{V_\ell} = \frac{1}{274}$

13. The radius of which of the following orbits is same as that of the first Bohr's orbit of hydrogen atom?

a. He^{+} (n = 2) b. Li^{2+} (n = 2) c. Li^{2+} (n = 3) d. Be^{3+} (n = 2)

D

Sol. $R_H = 0.529$ Å

$$r_{Be^{3+}} = \frac{r_H \times n^2}{Z}$$

$$= \frac{0.529\ \text{Å} \times 2 \times 2}{4} = 0.529\ \text{Å}$$

14. If the energy difference between the ground state of an atom and its excited state is 4.4×10^{-14} J, the wavelength of photon required to produce the transition:

a. 2.26×10^{-12} m b. 1.13×10^{-12} m c. 4.52×10^{-16} m d. 4.52×10^{-12} m

D

Sol. $\Delta E = h\nu = \frac{hc}{\lambda}$ or $\lambda = \frac{hc}{\Delta E}$

$$= \frac{6.62 \times 10^{-34}\,\text{Js} \times 3 \times 10^{8}\,\text{m s}^{-1}}{4.4 \times 10^{-14}\,\text{J}}$$

$= 4.52 \times 10^{-12}$ m

15. The splitting of spectral lines under the influence of an electric field is called:

a. Raman effect b. Zeeman effect c. Compton effect d. Stark effect

D

16. Which experimental observation correctly account for the phenomenon?

	Experimental observation	**Phenomenon**
a.	X-rays spectra	atomic mass
b.	α-particle scattering	Quantized electron orbit
c.	Photoelectric effect	wave nature
d.	Emission spectra	Quantization of energy

D

Sol. Emission spectrum is key note of quantization of energy

17. According to Bohr's theory the angular momentum of an electron in the fourth orbit is

a. $\frac{h}{2\pi}$ b. $\frac{2h}{\pi}$ c. $\frac{3h}{2\pi}$ d. $\frac{3h}{\pi}$

B

Sol. Angular momentum of an electron is given as

$$m\,\upsilon\,r = \frac{nh}{2\pi}$$

18. Which of the following concerning Bohr's model is false?

a. Predicts that probability of electron near nucleus is more

b. Angular momentum of electron in H atom = $\frac{nh}{2\pi}$

c. Introduces the idea of stationary states

d. Explains line spectrum of hydrogen.

A

Sol. Bohr's model does not talk about probability of electrons.

19. The energy required to remove an electron from metal X is 3.31×10^{-19} J. The maximum wavelength of light that can photoeject an electron from metal X is

a. 6.0×10^{-6} m   b. 60 nm   c. 600 nm   d. 5×10^{-6} m

C

Sol. $E = \frac{hc}{\lambda}$

$\lambda = \frac{hc}{E} = \frac{6.62 \times 10^{-34}\ Js \times 3 \times 10^{8}\ m\,s^{-1}}{3.31 \times 10^{-19}\ J}$ = 6×10^{-7} m = 600 mm

20. The energy of first shell in hydrogen is -13.6 eV. The energy of second shell will be:

a. -3.4 eV   b. -10.2 eV   c. -1 eV   d. 3.02 eV

A

21. The number of photons of light having wave number 'x' in 2 J of energy source is

a. 2hcx   b. $\frac{hc}{2x}$ c. $\frac{2}{hcx}$ d. $\frac{2x}{hc}$

C

Sol. $E = nh\nu = \frac{nhc}{\lambda} = nhc\bar{\nu}$ $\left(\because \bar{\nu} = \frac{1}{\lambda}\right)$

as $E = 2J$

$\therefore$ $2 = nhc\bar{\nu}$ or $n = \frac{2}{hc\bar{\nu}} = \frac{2}{hcx}$

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

a. 8 : 1   b. 1 : 8   c. 1 : 1   d. 1 : 32

D

Sol. $T \propto \frac{n^3}{Z^2};\ \frac{T_{1,2}}{T_{2,1}} = \frac{1}{4} \times \frac{1}{8} = \frac{1}{32}$

23. Which of the following statement is not correct about photoelectric effect?

a. It established the existence of photons
b. The energy of the ejected electron is proportional to the frequency of the radiation
c. Increase in intensity of photo light increases photo current
d. The photoelectric effect explain the wave nature of light

D

24. The ratio of angular momentum of electron in two successive orbit is a (a > 1) and their difference is b. Then a/b is equal to :

a. $\frac{n}{n+1}$ b. $\frac{n+1}{n}$ c. $\frac{n+1}{n}.\frac{h}{2\pi}$ d. $\frac{n+1}{n}.\frac{2\pi}{h}$

D

Sol. Angular momentum in two successive orbitals are $\frac{nh}{2\pi}$ and $(n+1)\frac{h}{2\pi}$

$\therefore$ $a = \frac{n+1}{n}$ and $b = \frac{h}{2\pi}$

$\therefore$ $\frac{a}{b} = \frac{n+1}{n}.\frac{2\pi}{h}$

25. An electron is moving round the nucleus of a hydrogen atom in a circular orbit of radius r. The coulombic force $\vec{F}$ between the two is : $\left(K = \frac{1}{4\pi\varepsilon_0}\right)$

a. $\frac{2Ke^2}{r^2}$ b. $-\frac{2e^2K}{Kr^2}$ c. $\frac{e^2}{Kr^2}$ d. $\frac{-Ke^2}{r^2}$

D

Sol. $F = K\,\frac{Q_1 \times Q_2}{r^2}$

26. In which of the following systems will the radius of the first orbit is minimum :

a. Doubly ionized lithium b. Singly ionized helium
c. Deuterum atom d. Hydrogen atom

A

Sol. $r_1 = \frac{r_{1_H} \times n^2}{Z} = \frac{0.529 \times n^2}{Z}$

$\therefore \quad r_1 \propto \frac{1}{Z}$

27. The work function for metals A, B and C respectively and 1.92 eV, 2.00 eV and 5.0 eV. Which of them will emit photo electrons if exposed to radiations of wavelength 4100 Å.

a. A only b. A and B only c. All of these d. None of these

B

Sol. $E = hv = \frac{hc}{\lambda} = \frac{6,.6 \times 10^{-34} \times 3.0 \times 10^{8}}{4100 \times 10^{-10} \times 1.6 \times 10^{-19}}$ eV = 3 eV

Work function should be lower than 3eV to eject electron

28. The angular momentum of electron in hydrogen atom is proportional to:

a. $\sqrt{r}$ b. $\frac{1}{r}$ c. r^2 d. $\frac{1}{\sqrt{r}}$

A

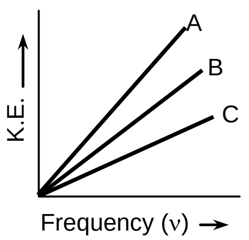
Sol. Angular momentum = $\frac{nh}{2\pi}$

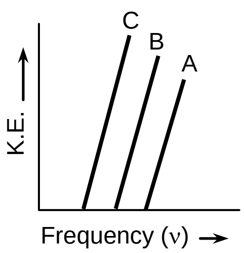
$r = \frac{n^2}{Z} \times 0.529\text{Å}$

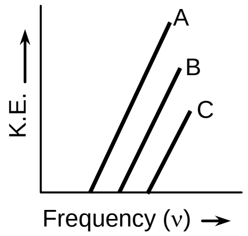
$n \propto \sqrt{r}$

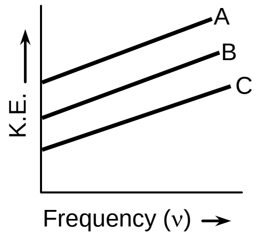
$\therefore$ Angular momentum $\propto \sqrt{r}$

29. Photoelectron emission is observed for three different metals A, B and C. The kinetic energy of the fastest photoelectrons versus frequency 'ν' is plotted for each metal. Which of the following graph shows the phenomenon correctly? [If A, B, C are Na, K, Cs]

a. 

b. 

c. 

d. 

B

So. Kinetic energy of photoelectrons increases with increase in frequency of incident radiation. The graphs for three metals A, B, C will be parallel to each other & threshold frequency will be lowest for C.

SECTION – B (Assertion and Reason) Negative Marking

This Section contains **6 multiple choice questions.** Each question has four choices A), B), C) and D) out of which **ONLY ONE** is correct. **6 × 3 = 18 Marks**

(A) Statement–1 & Statement -2 are true; Statement – 2 is the correct explanation of Statement -1.
(B) Statement–1 & Statement -2 are true but Statement–2 is not a correct explanation for Statement-1.
(C) Statement – 1 is true and Statement -2 is false.
(D) Statement – 1 is false and Statement -2 is true.

1. **Statement – 1:** $\frac{\text{Charge}}{\text{Mass}}$ ratio of anode rays is found different for different gases.

Statement -2: Color in discharge tube depend on nature of gas.

a. (a) b. (b) c. (c) d. (d)

B

Sol. e/m ratio of anode rays varies with the gas filled in the discharge tube.

2. **Statement-1:** Kinetic energy of photoelectrons is linearly proportional to the frequency of the incident radiation.

Statement-2: Each photon of light causes the emission of only one photoelectron.

a. (a) b. (b) c. (c) d. (d)

B

Sol. Kinetic energy of photoelectron depend on the ν of incident radiation. According to the Einstein's theory of photoelectric effect, one photon can eject only one photoelectron from the metal surface.

3. **Statement-1:** The shortest wavelength of transition of Lyman series is observed when electron jumps from orbit number, n =∞ to n = 1.

Statement-2: Since the wavelength of transition is given by $\frac{hc}{\lambda} = \Delta E$, maximum energy transition will have lowest λ.

a. (a) b. (b) c. (c) d. (d)

A

4. **Statement-1:** Limiting line in the Balmer series of H – spectrum has a wavelength of $\frac{4}{R_H}$

Statement-2: Limiting line is obtained for a jump of electron from n = 3 to n = 2.

a. (a) b. (b) c. (c) d. (d)

C

5. **Statement-1:** Photoelectric effect prove wave nature of Radiation
Statement-2: Photocurrent depend on intensity of incident Radiation

a. (a) b. (b) c. (c) d. (d)

D

6. **Statement-1:** Bohr's theory is based on Plank's quantum Mechanics
Statement-2: Concept of stationary state for electron was given by Bohr.

a. (a) b. (b) c. (c) d. (d)

B

SECTION – C (Paragraph Type)

This Section contains **3 paragraphs.** Each of these questions has four choices A), B), C) and D) out of which **ONLY ONE** is correct. (Mark only one) **9 × 3 = 27 Marks**

Passage – 1

According to Planck's quantum theory of radiation, the radiant energy is emitted or absorbed discontinuously in the form of quanta. The energy of a quantum is given by $E = h\nu$, where ν is the frequency of radiation. Moreover, a body can emit or absorb energy only in an integral multiple of quantum.

1. Planck's quantum theory of radiation favours the following nature of electromagnetic radiation:

a. Particle nature b. Wave nature c. Dual nature d. none of these

C

2. The energy associated with one photon of wavelength 3000 Å is:

a. 5.42×10^{-19} J b. 6.63×10^{-19} J c. 3.73×10^{-16} J d. 3.73×10^{-19} J

B

3. Which of the following is not the correct representation of Einstein's photoelectric equation?

a. $\frac{1}{2}m\upsilon^2 = h(\upsilon + \upsilon_0)$ b. $h\upsilon = h\upsilon_0 + \frac{1}{2}m\upsilon^2$

c. $h\upsilon = W + \frac{1}{2}m\upsilon^2$ (W = Work Function) d. $\frac{1}{2}m\upsilon^2 = h(\upsilon - \upsilon_0)$

A

Passage –2

According to Bohr's theory, the energy released during the de – excitation of electron in an atom is quantized and is equal to the difference of the energies of the two levels. When an electron jumps from n_2 energy level to n_1 level, the energy released corresponds to the wave number given by the following equation

$$\bar{\upsilon} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

Where R is constant called Rydberg constant. Its value is found to e equal to 109679 cm^{-1}. Each transition of electron from a higher energy level to a lower energy level gives rise to a discrete spectral line in the emission spectrum of the atom under consideration.

4. The name and the region of the series of spectral lines in hydrogen spectrum obtained by the transition of an electron from n_2 = 4, 5, 6, 7, ….. to n_1 = 3 are:

a. Paschen series, U.V.
b. Balmer series, visible
c. Paschen series, I.R.
d. Balmer series, U.V.

C

5. A spectral line in the Balmer series of hydrogen spectrum corresponds to 6561Å. The transition involved is:

a. $2 \rightarrow 1$ b. $3 \rightarrow 2$ c. $4 \rightarrow 3$ d. $5 \rightarrow 2$

B

6. To which of the following is Bohr's theory applicable?

a. B^{+4} b. Li^{+} c. Be^{2+} d. O^{2-}

A

Paragraph-3

Elements are composed of tiny particles known as atoms. Atoms are made of fundamental particles (e,p,n). According to Rutherford's Atomic Model p, n are located in Nucleus. Bohr's model explained the existence of circular orbits (energy levels) around the nucleus. Bohr's model can explain the spectrum of hydrogenic species and helps in find e,v,r (energy, velocity and radius) in nth orbit.

7. The ratio of r_4 and r_3 for hydrogen atom and that of Li^{+2} ion:

a. 1 : 3 b. 3 : 1 c. 1 : 9 d. 16 : 3

D

Sol. $\frac{r_H}{r_{Li+2}} = \frac{n_H^2}{n_{Li+2}^2} \times \frac{Z_{Li+2}}{Z_H} = \frac{4^2}{3^2} \times \frac{3}{1}$

8. The value of electro static potential energy between two charged particle

a. mv^2 b. $\frac{Ze^2}{r}$ c. $\frac{1}{4\pi \in_0} \times \frac{q_1q_2}{r}$ d. $\frac{1}{4\pi \in}\frac{Ze^2}{r}$

C

9. In an orbit the velocity of an electron in excited state of H-atom is 1.093×10^8 cm/s. What is the circumference in this orbit.

a. 6.65 Å b. 13.3 Å c. 3.33 Å d. 26.65 Å

B

Sol. $V = \frac{2.18 \times 10^8 \times z}{n}$

n = 2

Circumference = $2\pi r$

$= 2 \times \frac{22}{7} \times 0.529 \times 2^2$ Å

= 13.3 Å

SECTION – D (More than One Answer Type) Negative Marking

This Section contains **3 multiple choice questions.** Each question has four choices A), B), C) and D) out of which **ONE OR MORE** may be correct. **3 × 3 = 9 Marks**

1. In an electron transition of hydrogen atom, orbit angular momentum of an electron may change by:

a. h b. $\frac{h}{\pi}$ c. $\frac{h}{2\pi}$ d. $\frac{h}{4\pi}$

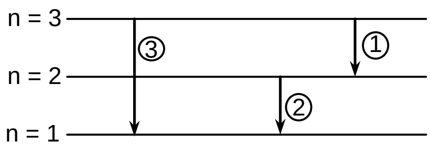
B, C

Sol. Change in angular momentum = $(n_2 - n_1)\frac{h}{2\pi}$

Possible values will be $\frac{h}{\pi}, \frac{h}{2\pi}, \frac{3h}{2\pi}$, …..

$\left(\text{h and } \frac{h}{4\pi} \text{ is not possible}\right)$

2.



For above transitions 1, 2 and 3 in hydrogen like atoms, select the correct relation(s).

a. $\nu_3 = \nu_1 + \nu_2$ b. $\nu_3 = \frac{\nu_1\nu_2}{\nu_1 + \nu_2}$ c. $\lambda_3 = \lambda_1 + \lambda_2$ d. $\lambda_3 = \frac{\lambda_1\lambda_2}{\lambda_1 + \lambda_2}$

A, D

Sol. $E_3 = E_1 + E_2$

$h\nu_3 = h\nu_1 + h\nu_2$

$\nu_3 = \nu_1 + \nu_2$

$\frac{c}{\lambda_3} = \frac{c}{\lambda_1} + \frac{c}{\lambda_2}$; $\frac{1}{\lambda_3} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$; $\lambda_3 = \frac{\lambda_1\lambda_2}{\lambda_1 + \lambda_2}$

3. Let r, V and E are the radius of the orbit, speed of the electron and the total energy of the electron respectively. Which of the following quantities are proportional to the No. of shell 'n'?

a. r × E b. vr c. $\frac{v}{E}$ d. $\frac{r}{E}$

B, C

Sol. $v = \frac{2.188 \times 10^8}{n}$ cm/sec

$r = n^2 \times 0.529 \times 10^{-8}$ cm

$E = -\frac{2.18 \times 10^{-18}}{n^2}$ J

(b) v × r

$\propto \frac{1}{n} \times n^2$

(c) $\frac{V}{E} \propto \frac{1}{n} \times n^2$

These relations show that vr and $\frac{v}{E}$ will be proportional to the principal quantum number.

SECTION – E (Matrix Type)

This Section contains **2 questions.** Each question has four choices (A, B, C and D) given in **Column I** and five statements (p, q, r, and s) in **Column II.** **8 × 2 = 16 Marks**

1. Match the **Column-I** with **Column-II.**

	Column I		Column II
(A)	$\frac{\text{Kinetic energy}}{\text{Potential energy}}$	**(p)**	2
(B)	Potential energy + 2 × Kinetic energy	**(q)**	- 1/2
(C)	$\frac{\text{Potential energy}}{\text{Total energy}}$	**(r)**	- 1
(D)	$\frac{\text{Kinetic energy}}{\text{Total energy}}$	**(s)**	0

Sol. **A→ q; B → s; C → p, D → r**

2. **Match Column – I with Column – II**

	Column – I		Column – II
(A)	Radius of Bohr orbit	(P)	Increases on increasing shell number
(B)	Kinetic energy of an electron in Bohr orbit	(Q)	Proportional to n^2
(C)	Speed of an electron in Bohr orbit	(R)	Proportional to n^3
(D)	Time period of an electron in one complete revolution in a Bohr orbit	(S)	Increases on increasing atomic number

Sol. **(A) → P,Q; (B) → S; (C) → S; (D) → P,R**

(A) $r_n = \frac{0.529n^2}{Z} \Rightarrow P, Q$

(B) $K.E. = 21.7 \times 10^{-19} \frac{Z^2}{n^2} \Rightarrow S$

(C) $V_n \propto \frac{Z}{n} \Rightarrow S$

(D) $\tau \propto \frac{n^3}{Z^2} \Rightarrow P, R$

SECTION – F (Integer Type) No Negative Marking

This Section contains **6 questions**. The answer to each question is a **Single Digit Integer** ranging from 0 to 10. The correct digit below the question number in the ORS is to be bubbled. **6 × 3 = 18**

1. An electron in the ground state of H atom absorbs energy equal to 10.2 eV. Find the excited state to which the electron will be promoted.

Sol. **1**

Energy of electron in ground state = -13.6 eV

Energy supplied = 10.2 eV

T.E. = -3.4

$E_n = -13.6 \frac{Z^2}{n^2}$ eV

$\therefore \quad -13.6 \frac{Z^2}{n^2}$ eV = -3.4 eV

$$\frac{-13.6}{n^2}\,eV = -3.4\ eV$$

$$n^2 = \frac{13.6}{3.4}\ ;\ n^2 = 4\ ;\quad \therefore\ n = 2$$

2. Ionisation potential of hydrogen atom is 13.6 eV. If ground state of H-atom is excited by monochromatic radiations of 12.1 eV, then number of spectral lines emitted by H-atom on deexcitation will be:

Sol. $E_n = -\frac{13.6}{n^2}$ Also $E = E_n - E_0$

$$12.1 = -\frac{13.6}{n^2} + 13.6$$

$\therefore$ n = 3

Thus, deexcitation will lead spectral lines = $\Sigma\Delta n = \Sigma(3 - 1) = 3$

3. The speed of electron in the first orbit of hydrogen atom is $2 \times 10^6\ ms^{-1}$. The speed of the electron in the same orbit of He^+ atom is $x \times 10^6\ ms^{-1}$, x is

Sol. $(\upsilon)_{He^+} = Z\,(\upsilon)_H = 2 \times 2 \times 10^6$

$= 4 \times 10^6\ ms^1$

= **4**

4. The amount of energy required to remove the electron from a Li^{2+} ion in its ground state is how many times greater than the amount of energy required to remove the electron from an H-atom in its ground state:

Sol. $E_{Li^{2+}} = E_H \times Z^2$

$\therefore\ \frac{E_{1Li^{2+}}}{E_{1H}} = Z^2 = 3^2 =$ **9**

5. What would be the maximum number of emission lines for atomic hydrogen that you would expect to see with the naked eye if the only electronic energy levels involved are those as shown in the Figure?

Sol. 5 [7 – 2; 6 – 2; 5 – 2; 4 – 2; 3 – 2]

6. The speed of an electron in an orbit of hydrogen atom is 4.37×10^5 m/sec. Total number of waves formed by the electron in one complete revolution in this orbit.

Sol. 5

According to Bohr's theory,

$$V_n = \frac{2.18 \times 10^6\ Z}{n}\ m/sec$$

For Hydrogen atom, Z = 1

$$\therefore\ n = \frac{2.18 \times 10^6}{V_n} = \frac{2.18 \times 10^6}{4.37 \times 10^5} = (5)$$

According to de Broglie, total number of waves made by an electron in one complete revolution $\Rightarrow$ Shell number = (5)