PHYSICAL CHEMISTRY

DPP

DAILY PRACTICE PROBLEMS

DPP No. 17

Total Marks : 36

Max. Time : 38 min.

Topic : Atomic Structure

Type of Questions		M.M., Min.
Single choice Objective ('–1' negative marking) Q.1 to Q.4,10	(3 marks, 3 min.)	[15, 15]
Multiple choice objective ('–1' negative marking) Q.5	(4 marks, 4 min.)	[4, 4]
Comprehension ('–1' negative marking) Q.6 to Q.8	(3 marks, 3 min.)	[9, 9]
Match the Following (no negative marking)(2 × 4) Q.9	(8 marks, 10 min.)	[8, 10]

1. The wavenumber of the spectral line of shortest wavelength of Balmer series of He^+ ion is :
(R = Rydberg's constant)
(A) R (B) 3R (C) 4R (D) 4R/9

2. Last line of the Lyman series of H-atom has frequency ν_1, last line of Lyman series of He^+ ion has frequency ν_2 and 1st line of Lyman series of He^+ ion has frequency ν_3. Then :
(A) $4\nu_1 = \nu_2 + \nu_3$ (B) $\nu_1 = 4\nu_2 + \nu_3$ (C) $\nu_2 = \nu_3 - \nu_1$ (D) $\nu_2 = \nu_1 + \nu_3$

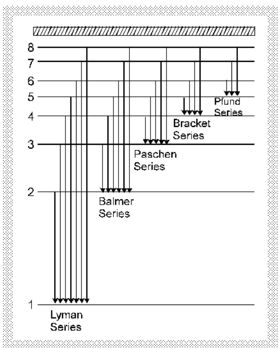
3. If λ_1 and λ_2 are respectively the wavelengths of the series limit of Lyman and Balmer series of Hydrogen atom, then the wavelength of the first line of the Lyman series of the H-atom is :
(A) $\lambda_1 - \lambda_2$ (B) $\sqrt{\lambda_1\lambda_2}$ (C) $\frac{\lambda_2 - \lambda_1}{\lambda_1\lambda_2}$ (D) $\frac{\lambda_1\lambda_2}{\lambda_2 - \lambda_1}$

4. **STATEMENT -1:** We can use two photons successively of 1240 Å and 2000 Å wavelength in order to ionise a H atom from ground state.
STATEMENT -2: Sum of the energies of both the photons is greater than IE of H atom.
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

5. Which of the following statements is/are INCORRECT :
(A) All spectral lines belonging to Balmer series in Hydrogen spectrum lie in visible region.
(B) If a light of frequency ν falls on a metal surface having work function $h\nu$, photoelectric effect will take place only if $\nu \le \nu_0$.
(C) The number of photoelectrons ejected from a metal surface in photoelectric effect depends upon the intensity of incident radiations.
(D) The series limit wavelength of Balmer series for H-atom is $\frac{4}{R}$, where R is Rydberg's constant.

Comprehension # (Q.6 to Q.8)]

The only electron in the hydrogen atom resides under ordinary conditions in 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 an electron jumps 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 :

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

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 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 lowest energy'.

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

6. In a hydrogen like sample, electrons are in a particular excited state. If electrons make transition upto 1^{st} excited state, then it produces maximum 15 different types of spectral lines. Then, electrons were initially in :

(A) 5^{th} state (B) 6^{th} state (C) 7^{th} state (D) 8^{th} state

7. The difference between the wave number of 1^{st} 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) $\frac{R}{4}$

8. In a single isolated atom of hydrogen, electrons make transition from 4^{th} excited state to ground state producing maximum possible number of wavelengths. If the 2^{nd} lowest energy photon is used to further excite an already excited sample of Li^{2+} ion, then transition will be :

(A) $12 \to 15$ (B) $9 \to 12$ (C) $6 \to 9$ (D) $3 \to 6$

9. **Match the following :**

List-I	List-II
(A) From n = 6 upto n = 3 (In H-atom sample)	(p) 10 lines in the spectrum
(B) From n = 7 upto n = 3 (In H-atom sample)	(q) Spectral lines in visible region
(C) From n = 5 upto n = 2 (In H-atom sample)	(r) 6 lines in the spectrum
(D) From n = 6 upto n = 2 (In H-atom sample)	(s) Spectral lines in infrared region

10. A photon of frequency $\frac{3Rc}{4}$ cannot be emitted from which of the following transitions :

(Given : R = Rydberg's constant, c = speed of light)

(A) From 5 upto 1 transition in a sample of H– atom.

(B) From 6 upto 1 transition in a sample of He^+ ion.

(C) From 7 upto 3 transition in a sample of Li^{2+} ion.

(D) From 8 upto 3 transition in a sample of He^+ ion.

Answer Key

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1.	(A)	**2.**	(D)	**3.**	(D)	**4.**	(D)	**5.**	(A, B)
6.	(C)	**7.**	(D)	**8.**	(B)				

9. [A $\rightarrow$ r, s] ; [B $\rightarrow$ p, s] ; [C $\rightarrow$ q, r, s] ; [D $\rightarrow$ p, q, s].   **10.** (D)

Hints & Solutions

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1. $Z = 2 \quad n_1 = 2 \quad n_2 = \infty$

$$\bar{\nu} = R\,(2)^2 \left(\frac{1}{2^2} - \frac{1}{\infty^2}\right) = R$$

2. $h\nu_1 = 13.6$ eV

$h\nu_2 = 13.6 \times 2^2$ eV

$h\nu_3 = 13.6 \times 2^2 \times \frac{3}{4}$ eV

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

$\Rightarrow \nu_2 = \nu_1 + \nu_3$

3. (i) Series limit of Lyman series $\Rightarrow$ n = ∞ to n = 1.

(ii) Series limit of Balmer series $\Rightarrow$ n = ∞ to n = 2.

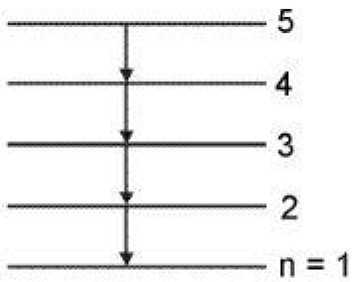
$E_{n = 2 \text{ to } n = 1} = E_{n = \infty \text{ to } n = 1} - E_{n = \infty \text{ to } n = 2}$

$$\frac{hC}{\lambda} = \frac{hC}{\lambda_1} - \frac{hC}{\lambda_2}$$

$$\bar{v}_2 = R \times \frac{3^2}{3^2} = R$$

$$\bar{v}_2 - \bar{v}_1 = \frac{5R}{4} - R = \frac{R}{4}$$

8.



$$\frac{n_1}{n_3} = \frac{n_2}{n_4} = \frac{z_1}{z_2}$$

Clearly 2nd lowest energy is $4 \rightarrow 3$ transition

hence transition is Li^{2+} having same energy is $9 \rightarrow 12$

9. (A) $6 \rightarrow 3$ $\quad \Delta n = 3$

$\therefore$ no. of lines = $\frac{3(3+1)}{2} = 6$. All lines are in infrared region

(B) $7 \rightarrow 3$ $\quad \Delta n = 4$

$\therefore$ no. of lines = $\frac{4(4+1)}{2} = 10$. All lines are in infrared region

(C) $5 \rightarrow 2$ $\quad \Delta n = 3$

no. of lines = $\frac{3(3+1)}{2} = 6$. All lines are in visible region

(D) $6 \rightarrow 2$ $\quad \Delta n = 4$

no. of lines = $\frac{4(4+1)}{2} = 10$. All lines are in visible region.

10. $\nu = RcZ^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

For $2 \rightarrow 1$ transition in H– atom sample, $\nu = Rc(1)^2 \left[\frac{1}{1^2} - \frac{1}{2^2}\right] = \frac{3Rc}{4}$

$\therefore (H)_{2 \rightarrow 1} = (He^+)_{4 \rightarrow 2} = (Li^{2+})_{6 \rightarrow 3}$

Thus, given photon is not emitted from $8 \rightarrow 3$ transition in He^+ ion sample.