Weird Chemist

Spectrum of Hydrogen Atom — DPP-6 Solutions

Chapter: Structure of Atom

"$1/\lambda = R\,Z^2(1/n_1^2 - 1/n_2^2)$ — yeh ek formula 40 questions solve kar sakta hai. Sirf n_1 aur n_2 sahi identify karo."

Master Formulae — Hydrogen Spectrum

- **Rydberg equation:** $\dfrac{1}{\lambda} = R\,Z^2\left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right)$; $n_2 > n_1$
- $R_H = 1.097 \times 10^7\ \text{m}^{-1} = 109678\ \text{cm}^{-1} = 1/912\ \text{Å}^{-1}$
- $\Delta E = 13.6\,Z^2\left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right)$ eV
- $\nu = c/\lambda$; $\bar{\nu} = 1/\lambda$; $E = h\nu$
- **Number of spectral lines:** $N = \dfrac{(n_2 - n_1)(n_2 - n_1 + 1)}{2}$
- **Series identification:** Lyman $n_1 = 1$; Balmer $n_1 = 2$; Paschen $n_1 = 3$; Brackett $n_1 = 4$; Pfund $n_1 = 5$; Humphrey $n_1 = 6$
- **Spectral line k in series:** starts at $n_2 = n_1 + k$. So 1st line: $n_2 = n_1 + 1$; 3rd line: $n_2 = n_1 + 3$
- **Shortest λ (highest energy)** in series: $n_2 = \infty$; $\lambda_{\text{min}} = 1/(R\,Z^2/n_1^2) = n_1^2/(R\,Z^2)$
- **Longest λ (lowest energy)** in series: $n_2 = n_1 + 1$
- **UV lines** = Lyman series ($n_1 = 1$); **Visible** = Balmer ($n_1 = 2$); **IR** = Paschen, Brackett, Pfund, Humphrey

TYPE 1 : Wavelength / Frequency / Energy Calculations of Transitions

Q.1 Which transition gives the LEAST energetic photon?

Explanation

$\Delta E \propto Z^2(1/n_1^2 - 1/n_2^2)$. Least energy $\Rightarrow$ smallest Δn aur highest n values.

- $n = 5 \to 3$: $1/9 - 1/25 = 16/225$
- $n = 6 \to 1$: $1 - 1/36 = 35/36$ (very large)
- $n = 5 \to 4$: $1/16 - 1/25 = 9/400$
- $n = 6 \to 5$: $1/25 - 1/36 = 11/900$ (smallest)

$n = 6 \to 5$ gives the minimum energy difference.

Concept

Least energy $\Rightarrow$ levels ke beech minimum gap $\Rightarrow$ adjacent high-n levels. Higher n mein levels closer hoti hain. $n = 6 \to 5$ ka gap sabse chota hai.

Answer

Option (4): $n = 6$ **to** $n = 5$

Q.2 Which transition requires the LARGEST amount of energy?

Explanation

Maximum energy = ionisation from ground state: $n = \infty$ to $n = 1$ (reverse = $n = 1 \to \infty$). $\Delta E = 13.6(1 - 0) = 13.6$ eV. Yeh maximum possible energy hai.

Answer

Option (3): $n = \infty$ **to** $n = 1$ (but this is absorption $n = 1 \to \infty$ = ionisation)

Common Student Mistake

"Largest energy" ke liye $n = 1 \to 2$ common distractor hai (10.2 eV). Lekin $n = 1 \to \infty = 13.6$ eV zyada hai. Jab bhi ∞ option ho, compare zaroor karo.

Q.3 Which emission transition gives MAXIMUM energy?

Explanation

All options: $n_3 \to n_2$, $n_4 \to n_3$, $n_5 \to n_4$ — sab adjacent transitions hain. $\Delta E = 13.6(1/n^2_{\text{lower}} - 1/n^2_{\text{upper}})$.

- $3 \to 2$: $13.6(1/4 - 1/9) = 13.6 \times 5/36 = 1.89$ eV
- $4 \to 3$: $13.6(1/9 - 1/16) = 13.6 \times 7/144 = 0.66$ eV
- $5 \to 4$: smaller still

$n_3 \to n_2$ gives maximum energy.

Answer

Option (1): $n_3 \to n_2$

Q.4 Maximum frequency of EMISSION for which transition?

Explanation

Maximum frequency = maximum energy emitted. Among given options, only (1) and (2) are emission transitions (higher $n \to$ lower n).

- $n = 2 \to 1$: $13.6(1 - 1/4) = 10.2$ eV
- $n = 6 \to 2$: $13.6(1/4 - 1/36) = 13.6 \times 8/36 = 3.02$ eV

$n = 2 \to 1$ gives higher energy/frequency.

Answer

Option (1): $n = 2$ **to** $n = 1$

Common Student Mistake

Options (3) and (4) are absorption transitions (lower$\to$higher n) — yeh emission nahi hain. Question "emission" poocha hai. Transition direction dhyan se dekho.

Q.5 LOW frequency emission — which transition?

Explanation

Low frequency = low energy = small energy difference. Among emission options:

- $n = 3 \to 1$: $13.6(1 - 1/9) = 12.09$ eV
- $n = 5 \to 2$: $13.6(1/4 - 1/25) = 13.6 \times 21/100 = 2.86$ eV (smaller)

$n = 5 \to 2$ gives lower energy/frequency. Options (1) and (2) are absorption (upward transitions).

Answer

Option (4): $n = 5$ **to** $n = 2$

Q.6 Minimum wavelength — which transition?

Explanation

Minimum λ = maximum energy. Calculate $1/n_1^2 - 1/n_2^2$ for each:

- $6 \to 4$: $1/16 - 1/36 = 5/144 = 0.0347$
- $4 \to 2$: $1/4 - 1/16 = 3/16 = 0.1875$
- $3 \to 1$: $1 - 1/9 = 8/9 = 0.889$ (maximum)
- $2 \to 1$: $1 - 1/4 = 3/4 = 0.75$

$3 \to 1$ has maximum ΔE among these, so minimum λ.

Answer

Option (3): $n = 3$ **to** $n = 1$

Common Student Mistake

Students often pick $n = 2 \to 1$ (Lyman series 1st line). But $n = 3 \to 1$ has larger energy gap — $8/9 > 3/4$. Always calculate, don't assume.

Q.7 For $n = 2 \to 1$, which species gives shortest wavelength?

Explanation

$1/\lambda = R\,Z^2(1/n_1^2 - 1/n_2^2)$. For same transition ($n_1 = 1, n_2 = 2$), factor $(1/1 - 1/4) = 3/4$ is same. So $1/\lambda \propto Z^2$: larger $Z \Rightarrow$ shorter λ.

- H: $Z = 1$; D: $Z = 1$; He^{+}: $Z = 2$; Li^{2+}: $Z = 3$ (maximum)

Li^{2+} has highest $Z \Rightarrow$ shortest λ.

Answer

Option (4): Li^{2+}

Common Student Mistake

D (deuterium) vs H: same $Z = 1$, toh same λ. Isotope change se wavelength nahi badhhti (Bohr formula mein mass nahi).

Q.8 Shortest wavelength line in H spectrum?

Explanation

Shortest λ = maximum energy transition. $n_4 \to n_1$: $\Delta E = 13.6(1 - 1/16) = 12.75$ eV — maximum among options. $n_4 \to n_3$ has much smaller energy.

Answer

Option (3): $n_4 \to n_1$

Q.9 Wavelength for $n = 3 \to 2$ in H? ($E_n = -1312/n^2$ kJ mol^{-1})

Explanation

$\Delta E = 1312(1/4 - 1/9) = 1312 \times 5/36 = 182.2$ kJ/mol
Per atom: $182.2 \times 10^3/(6.022 \times 10^{23}) = 3.026 \times 10^{-19}$ J
$\lambda = hc/E = (6.626 \times 10^{-34} \times 3 \times 10^8)/(3.026 \times 10^{-19}) = 6.57 \times 10^{-7}$ m $\approx 6.56 \times 10^{-7}$ m $= 656$ nm
Options (1) and (2) are both same value (6.56×10^{-7} m $= 65.6 \times 10^{-8}$ m $= 656$ nm), so any of the above applies for λ.

Answer

Option (4): Any of the above (all represent ≈ 656 nm in different units)

Common Student Mistake

Options (1) and (2) are same number: 6.56×10^{-7} m $= 656$ nm. Option (3) $= 65.6 \times 10^{-7}$ m $=$ 6560 nm — that's different! Only options (1) and (2) are equivalent. Answer key is (1) or equivalently (4) in context.

Q.10 Wavelength when $n = \infty \to 1$ in H. ($R = 1.097 \times 10^7$ m^{-1}) *[AIEEE 2004]*

Explanation

$1/\lambda = R(1/1^2 - 0) = R = 1.097 \times 10^7$ m^{-1}
$\lambda = 1/R = 1/(1.097 \times 10^7) = 9.116 \times 10^{-8}$ m $= 91.16$ nm ≈ 91 nm

Answer

Option (4): 91 nm

Common Student Mistake

Option (1) = 9.1×10^{-8} nm — yeh galatfehmi hai: 9.1×10^{-8} m $= 91$ nm, lekin option (1) unit nm mein hai, toh 9.1×10^{-8} nm bahut chota hai. Units mismatch trap.

Q.11 Wavelength for $n = \infty \to 1$ in He^+. ($R = 1.097 \times 10^7$ m^{-1})

Explanation

He^+: $Z = 2$. $1/\lambda = R \times Z^2 \times (1/1^2 - 0) = 4R = 4 \times 1.097 \times 10^7 = 4.388 \times 10^7$ m^{-1}
$\lambda = 1/(4.388 \times 10^7) = 2.279 \times 10^{-8}$ m $\approx 2.2 \times 10^{-8}$ m

Answer

Option (1): 2.2×10^{-8} m

Q.12 $n = 5 \to 2$ gives 434 nm. Find λ for $n = 4 \to 2$.

Explanation

Use ratio method: $\lambda \propto 1/\bar{\nu} = 1/(1/n_1^2 - 1/n_2^2)$

$$\frac{\lambda_{4\to2}}{\lambda_{5\to2}} = \frac{1/4 - 1/25}{1/4 - 1/16} = \frac{21/100}{3/16} = \frac{21}{100} \times \frac{16}{3} = \frac{336}{300} = 1.12$$

$\lambda_{4\to2} = 434 \times 1.12 = 486.1$ nm ≈ 486 nm

Concept

Direct calculation karne ki zaroorat nahi — ratio method use karo. $\lambda \propto 1/\Delta(1/n^2)$. Jo given hai usse divide karo.

Answer

Option (3): 486 nm

Q.13 Wavelength to excite H from $n = 1 \to 2$. ($E = -2.178 \times 10^{-18} Z^2/n^2$ J)

Explanation

$\Delta E = 2.178 \times 10^{-18}(1/1^2 - 1/4) = 2.178 \times 10^{-18} \times 3/4 = 1.6335 \times 10^{-18}$ J
$\lambda = hc/\Delta E = (6.62 \times 10^{-34} \times 3 \times 10^8)/(1.6335 \times 10^{-18})$
$= 19.86 \times 10^{-26}/1.6335 \times 10^{-18} = 12.16 \times 10^{-8}$ m $= 1.216 \times 10^{-7}$ m

Answer

Option (1): 1.214×10^{-7} **m**

Q.14 Frequency for $n = 4 \to 1$ in H. (IE $= 2.18 \times 10^{-18}$ J)

Explanation

$\Delta E = 2.18 \times 10^{-18}(1/1^2 - 1/16) = 2.18 \times 10^{-18} \times 15/16 = 2.044 \times 10^{-18}$ J
$\nu = \Delta E/h = 2.044 \times 10^{-18}/(6.626 \times 10^{-34}) = 0.3085 \times 10^{16} = 3.08 \times 10^{15}$ s^{-1}

Answer

Option (2): 3.08×10^{15} **s**$^{-1}$

Q.15 Frequency of He^+ ($n = 4 \to 2$) equals which H transition? *[AIEEE 2011]*

Explanation

For same frequency: $Z^2_{He^+}(1/n_1^2 - 1/n_2^2)_{He^+} = Z^2_H(1/n_1^2 - 1/n_2^2)_H$
$4 \times (1/4 - 1/16) = 1 \times (1/n_1^2 - 1/n_2^2)_H$
$4 \times 3/16 = 3/4 = (1/n_1^2 - 1/n_2^2)_H$
$1/1^2 - 1/2^2 = 3/4$ — matches $n = 2 \to 1$.

Concept

Condition for same frequency in different hydrogen-like species: $Z^2(1/n_1^2 - 1/n_2^2)$ must be equal. Set the two expressions equal and solve.

Answer

Option (2): $n = 2$ **to** $n = 1$

Q.16 Frequency for $n_1 = 2, n_2 = 4$. Series?
($R = 109677$ cm^{-1}, $c = 3 \times 10^8$ m/s)

Explanation

$n_1 = 2, n_2 = 4 \Rightarrow$ **Balmer series** ($n_1 = 2$).
$\bar{\nu} = R(1/4 - 1/16) = 109677 \times 3/16 = 20564.4$ cm^{-1}
$\nu = c\bar{\nu} = 3 \times 10^{10}$ cm/s $\times$ 20564.4 cm^{-1} $= 6.17 \times 10^{14}$ s^{-1} $\approx 6.172 \times 10^{14}$ s^{-1}

Answer

Option (1): 6.172×10^{14} **s^{-1}; Balmer series**

Common Student Mistake

c ko m/s mein diya hai lekin R cm^{-1} mein hai. Ya toh $c = 3 \times 10^{10}$ cm/s use karo, ya R ko m^{-1} mein convert karo. Unit mismatch se answer galat aata hai.

Q.17 Energy absorbed when $n = 1 \rightarrow 3$ in Bohr's model. In ergs?

Explanation

$\Delta E = 13.6(1 - 1/9)$ eV $= 13.6 \times 8/9 = 12.09$ eV
Convert to ergs: 1 eV $= 1.6 \times 10^{-12}$ ergs
$\Delta E = 12.09 \times 1.6 \times 10^{-12} = 19.34 \times 10^{-12}$ ergs $= 1.934 \times 10^{-11} \approx 0.1936 \times 10^{-10}$ ergs

Answer

Option (4): 0.1936×10^{-10} **ergs**

Common Student Mistake

1 eV $= 1.6 \times 10^{-19}$ J $= 1.6 \times 10^{-12}$ ergs (since 1 J $= 10^7$ ergs). Units mein erg rarely aata hai — yaad rakho yeh conversion.

Q.18 $\Delta E = 4.4 \times 10^{-19}$ J. Wavelength of photon?

Explanation

$\lambda = hc/E = (6.626 \times 10^{-34} \times 3 \times 10^8)/(4.4 \times 10^{-19})$
$= 1.988 \times 10^{-25}/4.4 \times 10^{-19} = 0.4518 \times 10^{-6}$ m $\approx 4.5 \times 10^{-7}$ m

Answer

Option (1): 4.5×10^{-7} **m**

Common Student Mistake

Options (2), (3), (4) use same number but different units: 4.5×10^{-7} nm $= 4.5 \times 10^{-16}$ m (too small), 4.5×10^{-7} Å (tiny). Answer is in metres: 4.5×10^{-7} m $= 450$ nm (visible, reasonable).

TYPE 2 : Spectral Series — Identification and Properties

Q.19 Third line of Balmer series?

Explanation

Balmer: $n_1 = 2$. kth line starts from $n_2 = 2 + k$. 3rd line: $n_2 = 5$. So transition $5 \rightarrow 2$.

Answer

Option (1): $5 \to 2$

Common Student Mistake

Sabse common mistake: Students 3rd line ko $n_2 = 4$ maan lete hain $(4 \to 2)$. 1st line: $3 \to 2$; 2nd line: $4 \to 2$; **3rd line:** $5 \to 2$. Rule: kth line $\Rightarrow n_2 = n_1 + k$.

Q.20 n_1 **for Paschen series?**

Explanation

Paschen series: electron $n_1 = 3$ orbit mein land karta hai. $n_1 = 3$.

Answer

Option (3): 3

Q.21 Third line in Balmer series?

Explanation

Same as Q.19: $5 \to 2$.

Answer

Option (1): $5 \to 2$

Q.22 Third line from the red end in Bohr series corresponds to?

Explanation

"From red end" means starting from the longest wavelength (lowest energy) line. In Balmer series: Red end (longest λ): 1st line $(3 \to 2)$; 2nd: $4 \to 2$; **3rd:** $5 \to 2$.

Answer

Option (2): $5 \to 2$

Q.23 $n = 4 \to 1$ **gives UV.** $n = 4 \to 2$ **gives which colour?**

Explanation

$n = 4 \to 2$ is in Balmer series $(n_1 = 2)$. Balmer series is in the **visible region**. $4 \to 2$ is the 2nd line of Balmer, which corresponds to blue-green colour (486 nm).

Answer

Option (2): Green (visible Balmer series line)

Q.24 Which series has highest energy in H spectrum?

Explanation

Highest energy = highest frequency = shortest wavelength = smallest n_1. Lyman series has $n_1 = 1$ (smallest), so all lines have the most energy. Lyman is in UV region.

Answer

Option (4): Lyman

Q.25 Which transition emits photon of maximum frequency?

Explanation

Maximum frequency = maximum energy. Compare all given lines:

- 1st Lyman: $2 \to 1$, $\Delta E = 10.2$ eV
- 2nd Balmer: $4 \to 2$, $\Delta E = 2.55$ eV
- 2nd Paschen: $5 \to 3$, $\Delta E = 0.97$ eV
- 5th Humphrey: $11 \to 6$, very small

1st Lyman line has maximum energy.

Answer

Option (4): First spectral line of Lyman series

Q.26 Smallest wavelength occurs for which series?

Explanation

Smallest λ overall = highest energy series = Lyman ($n_1 = 1$). The series limit (shortest λ) of Lyman is $\lambda = 1/R = 91.2$ nm, shorter than any line of other series.

Answer

Option (1): Lyman series

TYPE 3 : Hydrogen Spectrum — Wavelength

Q.27 Wavelength of 1st Balmer line. ($R = 1/912$ **Å**$^{-1}$)

Explanation

1st Balmer: $n_1 = 2, n_2 = 3$.
$1/\lambda = R(1/4 - 1/9) = R \times 5/36 = (1/912) \times 5/36$ Å^{-1}
$\lambda = 912 \times 36/5 = 912 \times 7.2 = 6566$ Å

Answer

Option (1): 6566 Å

Q.28 3rd line of Brackett series. ($R = 109678$ **cm**$^{-1}$)

Explanation

Brackett: $n_1 = 4$. 3rd line: $n_2 = 7$.
$1/\lambda = R(1/16 - 1/49) = 109678 \times (49 - 16)/(16 \times 49) = 109678 \times 33/784$
$= 109678 \times 0.04209 = 4616.5$ cm^{-1}
$\lambda = 1/4616.5 = 2.166 \times 10^{-4}$ cm $= 21660$ Å ≈ 21667 Å

Answer

Option (1): 21667 Å

Q.29 Maximum wavelength of Balmer series. ($R_H = 10^7$ **m**$^{-1}$)

Explanation

Maximum λ = minimum energy = 1st Balmer line ($3 \to 2$).
$1/\lambda = 10^7 \times (1/4 - 1/9) = 10^7 \times 5/36 = 1.389 \times 10^6$ m^{-1}
$\lambda = 7.2 \times 10^{-7}$ m $= 720$ nm

Answer

Option (1): 720 nm

Q.30 Shortest wavelength in Paschen series?

Explanation

Shortest λ = series limit: $n_2 = \infty, n_1 = 3$.
$1/\lambda = R/9 = 1.097 \times 10^7/9 = 1.219 \times 10^6$ m^{-1}
$\lambda = 8.2 \times 10^{-7}$ m $= 820$ nm ≈ 820.8 nm

Answer

Option (1): 820.8 nm

Q.31 Longest wavelength in Balmer series?

Explanation

Longest λ = 1st Balmer line ($3 \to 2$). From Q.27: 6566 Å $= 656.6$ nm ≈ 656 nm (H-alpha line, red colour).

Answer

Option (2): 656 nm

Q.32 Wavelength of 3rd Balmer line in terms of R?

Explanation

3rd Balmer: $n_1 = 2, n_2 = 5$.
$1/\lambda = R(1/4 - 1/25) = R \times 21/100$
$\lambda = 100/(21R)$

Answer

Option (2): $\frac{100}{21R}$

Q.33 1st Lyman H = 1216 Å. 1st Lyman for Na^{10+} ($Z = 11$)?

Explanation

$\lambda \propto 1/Z^2$. $\lambda_{\text{Na}^{10+}} = \lambda_H/Z^2 = 1216/121 \approx 10.05$ Å ≈ 10 Å

Answer

Option (3): 10 Å

Q.34 **Shortest λ Lyman $= x$. First Balmer line wavelength?**

Explanation

Shortest Lyman: $n_2 = \infty, n_1 = 1$: $1/\lambda^L_{\text{min}} = R \Rightarrow x = 1/R$.
First Balmer: $n_1 = 2, n_2 = 3$: $1/\lambda = R \times 5/36 \Rightarrow \lambda = 36/(5R) = 36x/5$.

Answer

Option (2): $36x/5$

Common Student Mistake

$x = 1/R$ — this is the key substitution. Phir $\lambda_{\text{Balmer\_1}} = 36/(5R) = 36x/5$. Students often substitute wrong series limit.

Q.35 **Which H transition has same λ as He^+ ($n = 4 \to 2$)?**

Explanation

For same λ: $Z_1^2(1/n_{1a}^2 - 1/n_{2a}^2) = Z_2^2(1/n_{1b}^2 - 1/n_{2b}^2)$
He^+: $4(1/4 - 1/16) = 4 \times 3/16 = 3/4$
H: $(1/n_1^2 - 1/n_2^2) = 3/4 = 1 - 1/4 = (1/1^2 - 1/2^2)$
So H transition: $n = 2 \to n = 1$.

Answer

Option (3): $2 \to 1$

Q.36 **Which He^+ transition has same λ as 1st Lyman of H?**

Explanation

1st Lyman H: $Z = 1$, $1/1^2 - 1/4 = 3/4$.
He^+: $Z = 2$: $4(1/n_1^2 - 1/n_2^2) = 3/4 \Rightarrow 1/n_1^2 - 1/n_2^2 = 3/16 = 1/4 - 1/16 = (1/2^2 - 1/4^2)$
So He^+ transition: $4 \to 2$.

Answer

Option (4): $4 \to 2$

TYPE 4 : Hydrogen Spectrum — Frequency and Wave Number

Q.37 **Frequency of last (limit) line of Lyman series.**
$(c = 3 \times 10^{10}\ \text{cm/s},\ R = 109678\ \text{cm}^{-1})$

Explanation

Last/limit line: $n_2 = \infty, n_1 = 1$.
$\bar{\nu} = R = 109678\ \text{cm}^{-1}$
$\nu = c\bar{\nu} = 3 \times 10^{10} \times 109678 = 3.29 \times 10^{15}\ \text{s}^{-1}$

Answer

Option (1): 3.29×10^{15} **s**$^{-1}$

Q.38 Limiting line frequency of Balmer series?

Explanation

Balmer limit: $n_2 = \infty, n_1 = 2$.
$\bar{\nu} = R/4 = 109678/4 = 27420\ \text{cm}^{-1}$
$\nu = 3 \times 10^{10} \times 27420 = 8.22 \times 10^{14}\ \text{s}^{-1}$

Answer

Option (3): 8.22×10^{14} **s**$^{-1}$

Common Student Mistake

Option (4) = -8.22×10^{-14} — frequency kabhi negative nahi hoti. Yeh trap hai.

Q.39 Wave number of 1st emission line of Balmer series?

Explanation

1st Balmer: $n_1 = 2, n_2 = 3$.
$\bar{\nu} = R(1/4 - 1/9) = R \times 5/36 = 5R/36$

Answer

Option (1): $5R/36$ **cm**$^{-1}$

Q.40 1st Balmer H = 15200 cm^{-1}. 1st Balmer of Li^{2+}?

Explanation

$\bar{\nu} \propto Z^2$. Li^{2+}: $Z = 3$.
$\bar{\nu}_{Li^{2+}} = 15200 \times Z^2 = 15200 \times 9 = 136800\ \text{cm}^{-1}$

Answer

Option (1): 136800 cm^{-1}

TYPE 5 : Hydrogen Spectrum — Ratio of Wavelength and Frequency

Q.41 Max λ of Lyman : Max λ of Balmer = ?

Explanation

Max λ = first line of each series (minimum energy).
1st Lyman ($2 \to 1$): $1/\lambda_L = R(1 - 1/4) = 3R/4 \Rightarrow \lambda_L = 4/(3R)$
1st Balmer ($3 \to 2$): $1/\lambda_B = R(1/4 - 1/9) = 5R/36 \Rightarrow \lambda_B = 36/(5R)$
Ratio: $\lambda_L : \lambda_B = 4/(3R) : 36/(5R) = 4/3 : 36/5 = 20 : 108 = 5 : 27$

Answer

Option (1): 5 : 27

Q.42 First line : second line of Paschen series?

Explanation

Paschen $n_1 = 3$. 1st line ($4 \to 3$): $1/\lambda_1 = R(1/9 - 1/16) = 7R/144$. 2nd line ($5 \to 3$): $1/\lambda_2 = R(1/9 - 1/25) = 16R/225$.
$\lambda_1/\lambda_2 = (16R/225)/(7R/144) = (16 \times 144)/(225 \times 7) = 2304/1575 = 256/175$

Answer

Option (1): 256 : 175

Q.43 Ratio of minimum λ of Lyman to Balmer?

Explanation

Min λ = series limit ($n_2 = \infty$).
Lyman limit: $\lambda_L^{\text{min}} = 1/R$. Balmer limit: $\lambda_B^{\text{min}} = 4/R$ (since $1/\lambda = R/4$).
Ratio: $\lambda_L^{\text{min}}/\lambda_B^{\text{min}} = (1/R)/(4/R) = 1/4 = 0.25$

Answer

Option (2): 0.25

Q.44 Ratio of 1st Lyman: Li^{2+} to 1st Lyman: deuterium?

Explanation

$\lambda \propto 1/Z^2$. Deuterium ($Z = 1$), Li^{2+} ($Z = 3$).
$\lambda_{Li^{2+}}/\lambda_D = Z_D^2/Z_{Li}^2 = 1/9$. So ratio $= 1 : 9$.

Answer

Option (1): 1 : 9

Q.45 Ratio of shortest λ of two series ≈ 9. Which series? *[JEE Main 2019]*

Explanation

Shortest λ of series with n_1: $\lambda_{\text{min}} = n_1^2/R$.
Ratio: $\lambda_{\text{min},A}/\lambda_{\text{min},B} = n_{1A}^2/n_{1B}^2 = 9 \Rightarrow n_{1A}/n_{1B} = 3$.
Series with n_1 ratio $3 : 1$: Lyman ($n_1 = 1$) and Paschen ($n_1 = 3$). $3^2/1^2 = 9$.

Answer

Option (3): Lyman and Paschen

Q.46 Ratio of minimum frequency of Lyman to Balmer?

Explanation

Min frequency = first line (smallest ΔE).
1st Lyman ($2 \to 1$): $\nu_L = Rc \times 3/4$.
1st Balmer ($3 \to 2$): $\nu_B = Rc \times 5/36$.
Ratio: $\nu_L/\nu_B = (3/4)/(5/36) = (3/4) \times (36/5) = 108/20 = 5.4$

Answer

Option (3): 5.4

Q.47 $(\nu_{\max})_{\textbf{Lyman}} : (\nu_{\max})_{\textbf{Brackett}}$ **= ?**

Explanation

Max ν = series limit (highest energy line: $n_2 = \infty$).
Lyman limit: $\bar{\nu}_L = R/1^2 = R$.
Brackett limit: $\bar{\nu}_{Br} = R/4^2 = R/16$.
Ratio: $\nu_L/\nu_{Br} = R/(R/16) = 16 : 1$

Answer

Option (2): 16 : 1

TYPE 6 : Number of Spectral Lines

Concept

Core formula: When electron transitions from n_2 to n_1 in multi-steps:
Total spectral lines $= \dfrac{(n_2 - n_1)(n_2 - n_1 + 1)}{2}$
For single atom: $N = n_2 - n_1$ (only one pathway possible at a time).
For a sample/collection of atoms: $N = \dfrac{(n_2 - n_1)(n_2 - n_1 + 1)}{2}$ (all possible transitions).

Lines in specific region:
- UV (Lyman): all transitions ending at $n = 1$: count $= (n-1)$ if starting from nth orbit to $n = 1$
- Visible (Balmer): ending at $n = 2$
- IR (Paschen+): ending at $n \geq 3$

Q.48 $n = 6 \to 2$ **(multi-step). Lines WITHOUT Balmer series?**

Explanation

Total lines from $n = 6 \to 2$: $(6-2)(6-2+1)/2 = 4 \times 5/2 = 10$.
Balmer lines: all transitions ending at $n = 2$ within range $n = 3, 4, 5, 6 \to 2$ = 4 lines.
Lines without Balmer $= 10 - 4 = 6$.
These are Paschen-type lines (3 $\to$ nothing below 2 in this case — actually lines between $n = 3, 4, 5, 6$ transitions not ending at $n = 2$): $\binom{4}{2} = 6$ lines among $n = 3, 4, 5, 6$.

Answer

Option (1): 6

Q.49 Atom with x energy levels. Total spectral lines?

Explanation

Total lines = number of pairs of levels $= \binom{x}{2} = x(x-1)/2 = 1 + 2 + 3 + \cdots + (x-1)$.

Answer

Option (3): $1 + 2 + 3 + \cdots + (x-1)$

Q.50 Emission lines NOT in absorption spectrum?

Explanation

Absorption occurs from ground state (lowest level X) upward. Only transitions *from X* appear in absorption: lines 1, 2, 3 (X to A, X to B, X to C).
Transitions between higher levels (4: A to B, 5: B to C... wait, relabel per figure) that do NOT start from X will not appear in absorption.
From the figure: X is ground state. Lines from X: lines that start at X = lines 1, 2, 3. Lines NOT from ground state (between excited levels B, C, A): lines 4, 5, 6 will NOT appear in absorption.

Answer

Option (3): 4, 5, 6

Common Student Mistake

Absorption sirf ground state se hoti hai (normal conditions). Excited state se excited state transitions emission mein hoti hain, absorption mein nahi. Jo lines X se start nahi karti — woh absorption mein nahi aayengi.

Q.51 3 UV lines during de-excitation to ground state. How many IR lines?

Explanation

3 UV lines = 3 Lyman lines = transitions $n = 2 \to 1, 3 \to 1, 4 \to 1 \Rightarrow$ electron was in $n = 4$ initially.
Total lines from $n = 4 \to 1$: $(4-1)(4-1+1)/2 = 3 \times 4/2 = 6$.
UV (Lyman): 3 lines.
Visible (Balmer, ending at $n = 2$): $3 \to 2, 4 \to 2$ = 2 lines.
IR (Paschen, ending at $n = 3$): $4 \to 3$ = 1 line.

Answer

Option (1): 1 IR line

Q.52 $n = 7 \to 1$ **(multi-step). Total lines?**

Explanation

$N = (7-1)(7-1+1)/2 = 6 \times 7/2 = 21$.

Answer

Option (1): 21

Q.53 $n = 6 \to 2$ **(multi-step). Total lines?**

Explanation

$N = (6-2)(6-2+1)/2 = 4 \times 5/2 = 10$.

Answer

Option (1): 10

Q.54 5 UV lines during de-excitation. How many IR lines?

Explanation

5 UV lines = 5 Lyman lines: $2 \to 1, 3 \to 1, 4 \to 1, 5 \to 1, 6 \to 1 \Rightarrow$ starting from $n = 6$.
Total lines $n = 6 \to 1$: $5 \times 6/2 = 15$.
UV: 5; Visible (Balmer): $3 \to 2, 4 \to 2, 5 \to 2, 6 \to 2$ = 4 lines.
IR (Paschen+): $15 - 5 - 4 = 6$ lines.

Answer

Option (1): 6 IR lines

Q.55 $n \to 1$ **gives 10 total lines. Find** n**.**

Explanation

$(n-1)n/2 = 10 \Rightarrow n(n-1) = 20 \Rightarrow n = 5$ (since $5 \times 4 = 20$).

Answer

Option (3): $n = 5$

Q.56 Balmer lines when $n = 7 \to 1$**?**

Explanation

Balmer lines = transitions ending at $n = 2$: $3 \to 2, 4 \to 2, 5 \to 2, 6 \to 2, 7 \to 2$ = **5 lines**.

Answer

Option (1): 5

Common Student Mistake

Balmer lines in $n = 7 \to 1$: all transitions ending at $n_1 = 2$ with $n_2 = 3, 4, 5, 6, 7$ = $(7-2) = 5$ lines. General formula: Balmer lines from nth orbit = $(n-2)$ lines.

Q.57 Max emission lines from $n = 5$ to ground state? *[NCERT Pg. 45]*

Explanation

$N = (5-1)(5-1+1)/2 = 4 \times 5/2 = 10.$

Answer

Option (2): 10

Q.58 Max lines when $n = 5 \to 1$?

Explanation

$N = (5-1) \times 5/2 = 10.$

Answer

Option (3): 10

Q.59 $n = 4 \to 1$. Spectral lines?

Explanation

$N = (4-1)(4-1+1)/2 = 3 \times 4/2 = 6.$

Answer

Option (2): 6

Q.60 UV lines from 5th excited ($n = 6$) to 1st excited ($n = 2$)?

Explanation

5th excited state: $n = 6$. 1st excited state: $n = 2$.
Transition range: $n = 2$ to $n = 6$.
UV = Lyman series (ending at $n = 1$). But in this transition, the lowest level is $n = 2$ — no transition ends at $n = 1$.
Therefore, **zero UV lines**.

Answer

Option (4): Zero

Common Student Mistake

UV lines = Lyman series = transitions ending at $n = 1$. Agar transition range mein $n = 1$ nahi hai, toh koi UV line nahi hogi. Yahan transition $n = 6 \to 2$ hai — $n = 1$ is not involved.

Q.61 IR lines from 5th excited ($n = 6$) to 1st excited ($n = 2$)?

Explanation

Transition $n = 6 \to 2$. Total lines $= 10$ (from Q.53).
Visible (Balmer, ending at $n = 2$): $3 \to 2, 4 \to 2, 5 \to 2, 6 \to 2$ = 4 lines.
UV: 0 (as per Q.60).
IR (Paschen+, ending at $n \geq 3$): transitions among $n = 3, 4, 5, 6$ not ending at $n = 2$: $\binom{4}{2} = 6$ lines.

Answer

Option (4): 6

Q.62 Balmer lines when electron de-excited from nth shell (to $n = 1$)?

Explanation

Balmer lines = transitions ending at $n = 2$: from $n = 3, 4, \ldots, n$ to $n = 2$ = $(n - 2)$ lines.
These are in the **visible region**.

Answer

Option (2): $(n - 2)$ **in visible region**

Q.63 4 energy levels shown $(n = 1, 2, 3, 4)$**. Emission lines?**

Explanation

Total emission lines = $\binom{4}{2} = 4 \times 3/2 = 6$.

Answer

Option (4): 6

Q.64 Same 4 levels. Absorption lines?

Explanation

Absorption sirf ground state $(n = 1)$ se hoti hai. Transitions: $1 \to 2$, $1 \to 3$, $1 \to 4$ = **3 absorption lines**.

Answer

Option (1): 3

Common Student Mistake

Emission aur absorption lines same nahi hoti. Emission = all possible downward transitions. Absorption = only from ground state upward (at normal temperature).

Q.65 9.9 eV supplied to H. Spectral lines emitted?

Explanation

H allowed excitation energies: $n = 1 \to 2$: 10.2 eV; $n = 1 \to 3$: 12.09 eV.
9.9 eV $<$ 10.2 eV — cannot excite to $n = 2$. No excitation possible.
Therefore, **0 spectral lines**.

Answer

Option (1): 0

Common Student Mistake

Photon ka energy exactly ek allowed transition ke barabar hona chahiye. 9.9 eV is less than 10.2 eV (minimum excitation energy). No partial excitation possible — atom won't interact with this photon.

TYPE 7 : Miscellaneous

Q.66 1st Lyman H: $\Delta E = 10.2$ eV. Same ΔE in 2nd Balmer transition of which ion?

Explanation

2nd Balmer: $n_1 = 2, n_2 = 4$. $\Delta E = 13.6 \times Z^2 \times (1/4 - 1/16) = 13.6 \times Z^2 \times 3/16$.
Set equal to 10.2: $13.6 \times Z^2 \times 3/16 = 10.2$
$Z^2 = 10.2 \times 16/(13.6 \times 3) = 163.2/40.8 = 4 \Rightarrow Z = 2 \Rightarrow$ He^+.

Answer

Option (3): He^+

Q.67 H: $n = 1 \to 2$ = 10.2 eV. Same transition in Be^{3+}?

Explanation

$\Delta E \propto Z^2$. Be^{3+}: $Z = 4$. $\Delta E = 10.2 \times Z^2 = 10.2 \times 16 = 163.2$ eV.

Answer

Option (2): 163.2 eV

Q.68 $\lambda \approx 900$ nm needed for heat treatment. Which H spectral line? *[JEE Main 2019]*

Explanation

Find which series/line has $\lambda \approx 900$ nm.
Paschen series ($n_1 = 3$) range: from ~ 820 nm (limit) to ~ 1875 nm (1st line).
$5 \to 3$ (3rd Paschen line): $1/\lambda = R(1/9 - 1/25) = R \times 16/225$
$\lambda = 225/(16R) = 225/(16 \times 1.097 \times 10^7) = 1.283 \times 10^{-6}$ m = 1283 nm
$\infty \to 3$ (Paschen limit): $\lambda = 9/R = 820$ nm
For $\lambda \approx 900$ nm: close to Paschen $\infty \to 3$ = 820 nm, or... let's check $5 \to 3$: 1283 nm (too high).
Looking at $\infty \to 3$: 820 nm (closest from Paschen limit side). Answer per JEE key: Paschen, $\infty \to 3$ (option 4) gives $\lambda = 820$ nm which is closest to 900 nm among options. But "Paschen $5 \to 3$" gives 1282 nm. The series limit ($\infty \to 3$) at 820 nm is closest to 900 nm.

Answer

Option (4): Paschen, $\infty \to 3$ ($\lambda = 820$ nm, closest to 900 nm)

Q.69 What potential is needed to emit first Paschen line from H in ground state?

Explanation

First Paschen line: $4 \to 3$. To emit this, electron must first reach $n = 4$ from ground state.
Energy needed: $\Delta E_{1\to4} = 13.6(1 - 1/16) = 13.6 \times 15/16 = 12.75$ eV.
So accelerating potential $= 12.75$ V.

Answer

Option (4): 12.75 V

Common Student Mistake

Paschen 1st line = $4 \to 3$, but to *produce* it the electron must reach $n = 4$ first (from $n = 1$). The potential needed = energy to go from $n = 1$ to $n = 4$, not the energy of the Paschen transition itself.

TYPE 8 : Theoretical Questions

Q.70 Why are line spectra of two elements not identical?

Explanation

Line spectrum uniquely identifies an element because each element has a unique electronic structure — different number of electrons and energy levels. Outermost electrons are at different energy levels in different elements $\Rightarrow$ different spectral lines.

Answer

Option (3): Their outermost electrons are at different energy levels

Q.71 He spectrum is similar to?

Explanation

He has 2 electrons — it's a multi-electron atom. Its spectrum is NOT similar to H. He^+ (1 electron) is hydrogen-like and would have a similar type of spectrum.

Answer

Option (3): He^+

Q.72 Which species gives spectral lines similar to Mg^{2+}?

Explanation

Mg^{2+}: $Z = 12$, 2 electrons removed, so 10 electrons remaining. It's a 10-electron species.
For similar spectrum, need same number of electrons: Al^{3+} has $Z = 13$, 3 electrons removed = 10 electrons. Same electronic structure.

Answer

Option (1): Al^{3+}

Q.73 H and He^+ transitions give λ_1 and λ_2. Relationship?

Explanation

Transitions not specified. General: for same n_1, n_2: $1/\lambda \propto Z^2$, so $\lambda \propto 1/Z^2$.
He^+ has $Z = 2$, so $\lambda_{He^+} = \lambda_H/4$, i.e. $\lambda_2 = \lambda_1/4$.
This assumes same quantum numbers for both transitions.

Answer

Option (4): $\lambda_2 = \lambda_1/4$ (for same n_1, n_2)

Q.74 In electronic transition, atom cannot emit?

Explanation

Electronic transitions between atomic energy levels involve energies of eV to keV range, corresponding to visible, UV, and soft X-rays. γ-rays require nuclear transitions (MeV energies) — atomic electron transitions cannot produce γ-rays.

Answer

Option (2): γ-rays

Q.75 $E_3 > E_2 > E_1$, transitions $\lambda_3, \lambda_2, \lambda_1$. Which is correct?

Explanation

Energy conservation: $E_{3\to1} = E_{3\to2} + E_{2\to1}$.
Since $E = h\nu = hc/\lambda$: $hc/\lambda_3 = hc/\lambda_2 + hc/\lambda_1$ (if λ_3 = 3-to-1, etc.)
$\Rightarrow 1/\lambda_3 = 1/\lambda_1 + 1/\lambda_2$ (wave numbers add, wavelengths do NOT add).
Also: $\nu_3 = \nu_1 + \nu_2$ (frequencies add for energy-conserving cascade).

Answer

Option (3): $\nu_3 = \nu_2 + \nu_1$

Common Student Mistake

Option (2): $\lambda_3 = \lambda_1 + \lambda_2$ — WRONG. Wavelengths don't add. Frequencies add because energies add: $h\nu_3 = h\nu_2 + h\nu_1$.

Q.76 In which transition is one quantum of energy emitted?

Explanation

Ek quantum = ek photon. Har bhi single electronic transition mein exactly ek photon emit hota hai. All options ($n = 4 \to 2$, $n = 3 \to 1$, $n = 4 \to 1$) emit exactly one photon each.

Answer

Option (4): All of them

Q.77 Which electronic level can absorb but NOT emit?

Explanation

Absorb requires electron to be in a level from which it can go higher (not already at maximum).
Emit requires the electron to be in an excited state (can fall to a lower level).
Ground state ($1s$) can absorb (go up) but cannot emit (cannot go lower). $1s$ is the ground state.

Answer

Option (4): 1s

Q.78 Spectrum of He^{+} similar to?

Explanation

He^{+} has 1 electron ($Z = 2$) — hydrogen-like species. Its spectrum has same *type* (series pattern) as H, just scaled by $Z^2 = 4$. Other 1-electron species: Li^{2+} ($Z = 3$), H ($Z = 1$), Li^{+} has 2 electrons.
Among options: Li^{+} has 2 electrons. H has 1 electron. H's spectrum is most similar in pattern.

Answer

Option (1): H

Common Student Mistake

He^{+} and H are both single-electron species — same pattern of spectral series (Lyman, Balmer etc.), just different wavelengths due to different Z. Li^{+} has 2 electrons and its spectrum is different. Q.71 aur Q.78 confuse mat karo: He spectrum $\neq$ H (He has 2 electrons), but He^{+} spectrum $\approx$ H (both 1-electron).

Answer Key — DPP-6

Q	A	Q	A	Q	A	Q	A	Q	A	Q	A	Q	A	Q	A
1	4	2	3	3	1	4	1	5	4	6	3	7	4	8	3
9	4	10	4	11	1	12	3	13	1	14	2	15	2	16	1
17	4	18	1	19	1	20	3	21	1	22	2	23	2	24	4
25	4	26	1	27	1	28	1	29	1	30	1	31	2	32	2
33	3	34	2	35	3	36	4	37	1	38	3	39	1	40	1
41	1	42	1	43	2	44	1	45	3	46	3	47	2	48	1
49	3	50	3	51	1	52	1	53	1	54	1	55	3	56	1
57	2	58	3	59	2	60	4	61	4	62	2	63	4	64	1
65	1	66	3	67	2	68	4	69	4	70	3	71	3	72	1
73	4	74	2	75	3	76	4	77	4	78	1				

"kth line of series $\Rightarrow n_2 = n_1 + k$. Yeh ek line yaad karo, Q.19, Q.21, Q.22 sab seedhe ho jaate hain."
— Weird Chemist