

**PHY • PHYSICS**

15. Atomic Spectra

Official PMDC Solved Past Paper Topical Booklet • High-Yield Examination Series

🎯 21 Solved Questions

📅 2022 to 2024 Archive

📋 Boards: BUMHS, DUHS, KMU, KU, SZABMU, UHS

📖 Weightage: 27% of MDCAT (54 MCQs)

Curated by Ibrahim for fellow bees. Every question in this chapter has been verified against official UHS, NUMS, SZABMU, DUHS, and KMU answer keys. Propolis cognitive autopsies are provided at the end of this booklet to explain core concepts and break down common distractor traps.

OFFICIAL SOLVED EDITION**Q1.**

SZABMU 2024

Which of the following series of hydrogen spectrum lies in visible region? [SZABMU 2024]

- (A) Balmer
- (B) Bracket
- (C) Lyman
- (D) Paschen

Q2.

SZABMU 2024

The Lyman series contain the wavelengths in the ____ of the hydrogen spectrum. [SZABMU 2024]

- (A) Far-infrared region
- (B) Infrared region
- (C) Ultraviolet region
- (D) Visible region

Q3.

KU 2024

If an electron in the hydrogen atom jumps from second to first orbit, the emitted radiation has a wavelength of? [KU 2024]

- (A) $4/3RH$
- (B) $3/4RH$
- (C) RH
- (D) $4RH$

Q4.

UHS 2024

Which series falls in ultra violet region? [UHS 2024]

- (A) Lyman
- (B) Brachett
- (C) Pfund
- (D) Paschen

Q5.

UHS 2024

The potential through which an electron should be accelerated, so that, on collision it can lift the electron in the atom from its ground state to same higher state is known as [UHS 2024]

- (A) Ionization potential
- (B) Excitation potential
- (C) String potential
- (D) Acceleration potential

Q6.

BUMHS 2024

According to the Bohr's model of an atom, the radius of the n^{th} orbit is proportional to: [BUMHS 2024]

- (A) n
- (B) $\sqrt{n}$
- (C) n^2
- (D) n^3

Q7.

UHS 2023

Which of the following is the longest wavelength of radiation for the Paschen series? [UHS 2023]

- (A) 187000000 m
- (B) 187000000 / m
- (C) 0.00000187 m
- (D) 0.00000187 / m

Q8.

UHS 2023

The Balmer series of hydrogen is important because it: [UHS 2023]

- (A) Is the only one for which the quantum theory can be used
- (B) Is in the visible region
- (C) Is the only series that occurs for hydrogen
- (D) Involves the lowest possible quantum number n

Q9.

SZABMU 2023

Which X-ray photon will have longest wavelength? [SZABMU 2023]

- (A) K_α
- (B) K_β
- (C) K_γ
- (D) M_α

Q10.

SZABMU 2023

Which of following series lies in infra-red region? [SZABMU 2023]

- (A) Lyman and Balmer
- (B) Paschen and Brackett
- (C) Brackett and Pfund
- (D) Both 'B' and 'C'

Q11.

DUHS 2023

In which spectral series is the for ultraviolet region of electromagnetic spectrum found? [SINDH 2023]

- (A) Paschen series
- (B) Balmer series
- (C) Lyman series
- (D) Pfund series

Q12.

DUHS 2023

An atom makes a transition from a state of energy E_2 to one of lower energy E_1 , which of the following gives the wavelength of the radiation emitted, in terms of the Planck constant h and the speed of light c ? [SINDH 2023]

- (A) $\frac{E_2 - E_1}{hc}$
- (B) $\frac{hc}{E_2 - E_1}$
- (C) $\frac{hc}{E_1 - E_2}$
- (D) $\frac{c}{h(E_2 - E_1)}$

Q13.

UHS 2022

The speed of electron in the first Bohr orbit is: [UHS 2022]

- (A) $2.19 \times 10^6 \text{ ms}^{-1}$
- (B) $2.19 \times 10^{-6} \text{ ms}^{-1}$
- (C) $2.19 \times 10^4 \text{ ms}^{-1}$
- (D) $2.19 \times 10^{-4} \text{ ms}^{-1}$

Q14.

SZABMU 2022

Which one of the following series lies in the ultraviolet region? [SZABMU 2022]

- (A) Balmer series
- (B) Paschen series
- (C) Lyman series
- (D) Brackett series

Q15.

SZABMU 2022

Which x-ray photon will have longest wavelength? [SZABMU 2022]

- (A) K_α
- (B) K_β
- (C) K_γ
- (D) M_α

Q16.

KMU 2022

The radiation emitted by warm blooded animals lies the region of: [ETEA 2022]

- (A) Visible
- (B) Ultraviolet
- (C) Infrared
- (D) X-rays

Q17.

KMU 2022

The shortest possible wavelength is associated with: [ETEA 2022]

- (A) Lyman series
- (B) Balmer series
- (C) Paschen series
- (D) Brackett series

Q18.

KMU 2022

The longest wavelength observed in Balmer series is: [ETEA 2022]

- (A) $36 / (5R_H)$
- (B) $36 / (7R_H)$
- (C) $36 / (11R_H)$
- (D) $36 / (13R_H)$

Q19.

KMU 2022

The shortest wavelength of Lyman series is ($R_H =$ Rydberg constant): **[ETEA 2022]**

- (A) R_H
- (B) $1/R_H$
- (C) $3R_H$
- (D) $5/R_H$

Q20.

DUHS 2022

If Rydberg constant for hydrogen is R_H then wave length ' λ ' of first line in Lyman series is **[DUHS 2022]**

- (A) $\frac{4R_H}{3}$
- (B) $\frac{R_H}{3}$
- (C) $\frac{4}{R_H}$
- (D) $\frac{4}{3R_H}$

Q21.

DUHS 2022

The kinetic energy of an electron in first Bohr radius of H – atom is: **[DUHS 2022]**

- (A) 13.6 J
- (B) 13.6 eV
- (C) -13.6 eV
- (D) 13.6 keV

RAPID 5–COLUMN ANSWER KEY

Official PMDC verified answer keys for 15. Atomic Spectra.

beambeprep.com

Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD
1	A	SZABMU 2024	6	C	BUMHS 2024	11	C	DUHS 2023	16	C	KMU 2022	21	B	DUHS 2022
2	C	SZABMU 2024	7	C	UHS 2023	12	B	DUHS 2023	17	A	KMU 2022			
3	A	KU 2024	8	B	UHS 2023	13	A	UHS 2022	18	A	KMU 2022			
4	A	UHS 2024	9	D	SZABMU 2023	14	C	SZABMU 2022	19	B	KMU 2022			
5	B	UHS 2024	10	D	SZABMU 2023	15	D	SZABMU 2022	20	D	DUHS 2022			

TOTAL MCQS
21

CORRECT

INCORRECT

BLANK

ACCURACY

%

Scan the booklet QR code to enter answers in **BeambePrep Grind Mode** for automated error autopsies.

PROPOLIS COGNITIVE ERROR AUTOPSIES

Step-by-step conceptual derivations, formula working, and distractor autopsies for every question.

Question #1 Key: (A)

SZABMU 2024

Which of the following series of hydrogen spectrum lies in visible region? [SZABMU 2024]

CORE CONCEPT AND DERIVATION

The hydrogen spectrum is organized into distinctive series based on the final orbital (p) that an electron transitions to. The visible light region is narrow (400–700 nm).

Formula:

$$\lambda = \frac{hc}{\Delta E}$$

Solution:

- The Balmer series is strictly defined by electrons falling from higher orbits down to the second orbit ($p = 2$).
- The energy gaps for these specific transitions (e.g., $n = 3 \rightarrow 2$, $n = 4 \rightarrow 2$) perfectly correspond to photons with wavelengths in the 400 nm to 700 nm range.
- This range is exclusively the Visible region of light for humans.

Why other options are incorrect:

Lyman (C) drops to $p = 1$, releasing massive energy as UV radiation. Paschen (D) and Brackett (B) drop to $p = 3$ and $p = 4$, releasing smaller energy amounts as invisible Infrared radiation.

Question #2 Key: (C)

SZABMU 2024

The Lyman series contain the wavelengths in the ____ of the hydrogen spectrum. [SZABMU 2024]

CORE CONCEPT AND DERIVATION

The Lyman series involves electron transitions terminating at the absolute ground state ($n = 1$) of the hydrogen atom, producing the most energetic spectral lines.

Formula:

$$E_{\text{photon}} = -13.6 \text{ eV} \left(\frac{1}{n^2} - \frac{1}{1^2} \right)$$

Solution:

- Since the transitions terminate at the deeply bound $n = 1$ shell, the energy difference ΔE is exceptionally large (between 10.2 eV and 13.6 eV).
- Photons with these energy levels correspond to wavelengths ranging from roughly 91 nm to 121 nm.
- This wavelength span sits firmly in the Ultraviolet (UV) spectrum, completely invisible to the human eye.

Why other options are incorrect:

Visible light (D) requires less energy (Balmer series). Infrared (B) and Far-infrared (A) require even less energy transitions, corresponding to series terminating at higher shells like Paschen or Brackett.

Question #3 Key: (A)

KU 2024

If an electron in the hydrogen atom jumps from second to first orbit, the emitted radiation has a wavelength of...

CORE CONCEPT AND DERIVATION

Wavelength of emitted radiation is mathematically derived from the Rydberg formula based on initial and final principal quantum numbers.

Formula:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{p^2} - \frac{1}{n^2} \right)$$

Solution:

- The electron transitions from the second orbit ($n = 2$) to the first orbit ($p = 1$).
- Substitute the values: $\frac{1}{\lambda} = R_H \left(\frac{1}{1^2} - \frac{1}{2^2} \right)$.
- Simplify the parentheses: $\frac{1}{\lambda} = R_H \left(1 - \frac{1}{4} \right) = R_H \left(\frac{3}{4} \right)$.
- To find λ , invert the equation: $\lambda = \frac{4}{3R_H}$.

Why other options are incorrect:

Option B ($\frac{3}{4}R_H$) is the un-inverted wave number ($1/\lambda$) rather than wavelength. Options C and D involve incorrect algebraic simplifications. Note: The source text formats the fraction exactly as $4/3R_H$.

Question #4 Key: (A)

UHS 2024

Which series falls in ultra violet region? [UHS 2024]

CORE CONCEPT AND DERIVATION

Spectral lines are grouped by the lowest energy state involved in the transition. The larger the atomic drop, the higher the energy and the shorter the wavelength.

Formula:

$$\text{Lyman} \implies p = 1$$

Solution:

- The Lyman series is defined by transitions down to the ground state ($n = 1$).
- Because the energy gap between $n = 1$ and any higher state is the largest in the hydrogen atom, these transitions yield the highest energy photons.
- High energy correlates with short wavelengths, placing these emissions entirely within the Ultraviolet (UV) light band.

Why other options are incorrect:

Brackett (spelled 'Brachett' in the original exam), Pfund, and Paschen all involve transitions to much higher orbits ($n = 4, 5, 3$ respectively). These smaller drops emit low-energy Infrared radiation.

Question #5 Key: (B)

UHS 2024

The potential through which an electron should be accelerated, so that, on collision it can lift the electron ...

CORE CONCEPT AND DERIVATION

In atomic physics, giving an atom enough energy to raise its electron from the ground state to a higher (but still bound) energy state is called "excitation."

Formula:

$$E = qV_{\text{excitation}} = E_{\text{higher}} - E_{\text{ground}}$$

Solution:

- When a free electron is accelerated through an electric potential V , it gains kinetic energy.
- If it collides with an atom and transfers this energy perfectly to lift the atom's bound electron to a higher shell, this specific voltage is defined as the "Excitation Potential."
- The electron is not completely removed from the atom; it merely jumps to a higher orbit.

Why other options are incorrect:

Ionization potential (A) is specifically the potential required to completely strip an electron from the atom (sending it to infinity), not just raise it to a higher shell. String potential (C) is a nonsense distractor term. Acceleration potential (D) is too generic and doesn't specify the bound-state atomic interaction.

Question #6 Key: (C)

BUMHS 2024

According to the Bohr's model of an atom, the radius of the [Formula] orbit is proportional to: [BUMHS 2024]

CORE CONCEPT AND DERIVATION

Niels Bohr derived the radius of atomic orbits by combining classical mechanics (centripetal force matching electrostatic force) with his quantum postulate regarding angular momentum.

Formula:

$$r_n = \frac{n^2 h^2}{4\pi^2 k m e^2}$$

Solution:

- In the formula above, all terms except n (Planck's constant h , Coulomb's constant k , electron mass m , and elementary charge e) are fundamental constants for a given atom.
- Grouping these constants together yields: $r_n = (\text{constant}) \times n^2$.
- For hydrogen, this simplifies to $r_n = 0.529 \text{ \AA} \times n^2$.
- Therefore, the radius scales quadratically; it is strictly proportional to n^2 .

Why other options are incorrect:

Options A, B, and D misrepresent the algebraic derivation. If the radius was simply proportional to n , the quantum spacing of atoms would be strictly linear rather than expanding vastly outward.

Question #7 Key: (C)

UHS 2023

Which of the following is the longest wavelength of radiation for the Paschen series? [UHS 2023]

CORE CONCEPT AND DERIVATION

The longest wavelength corresponds to the minimum energy transition in the Paschen series, which is from $n = 4$ to $p = 3$.

Formula:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{3^2} - \frac{1}{4^2} \right)$$

Solution:

- Using Rydberg's constant $R_H \approx 1.097 \times 10^7 \text{ m}^{-1}$.
- $\frac{1}{\lambda} = R_H \left(\frac{1}{9} - \frac{1}{16} \right) = R_H \left(\frac{16-9}{144} \right) = R_H \left(\frac{7}{144} \right)$.
- $\lambda = \frac{144}{7 \times 1.097 \times 10^7} \approx \frac{144}{7.679 \times 10^7} \approx 1.875 \times 10^{-6} \text{ m}$.
- In standard decimal form, $1.87 \times 10^{-6} \text{ m}$ is written as 0.00000187 m.

Why other options are incorrect:

Option A describes an absurdly massive distance. Options B and D are wave numbers ($1/\lambda$) rather than actual wavelengths, as indicated by the "/m" (per meter) units.

Question #8 Key: (B)

UHS 2023

The Balmer series of hydrogen is important because it: [UHS 2023]

CORE CONCEPT AND DERIVATION

Historically and practically, the Balmer series transitions (falling to the $p = 2$ level) fall directly into a specific, biologically and technologically relevant slice of the electromagnetic spectrum.

Formula:

$$\lambda_{\text{Balmer}} \in [400 \text{ nm}, 700 \text{ nm}]$$

Solution:

- The Balmer series represents transitions where photons possess energies between $\sim 1.9 \text{ eV}$ and 3.4 eV .
- These specific energy photons correspond to wavelengths between approximately 400 nm and 700 nm.
- This specific band is the "Visible Region" of the spectrum, making the Balmer series easily observable to the human eye, which is why it was historically the first series to be discovered and modeled.

Why other options are incorrect:

Quantum theory (A) applies universally to all series. Hydrogen exhibits many series (C is wrong). The lowest possible quantum number n (D) defines the Lyman series (ground state, $n = 1$), not Balmer.

Question #9 Key: (D)

SZABMU 2023

Which X-ray photon will have longest wavelength? [SZABMU 2023]

CORE CONCEPT AND DERIVATION

Photon wavelength is inversely proportional to the energy of the atomic transition. Longest wavelength equates to the lowest possible energy jump between shells.

Formula:

$$\Delta E = E_{\text{upper}} - E_{\text{lower}} = \frac{hc}{\lambda}$$

Solution:

- The inner shells (like K, $n = 1$) have massive binding energies. Transitions ending at the K-shell release large amounts of energy (short wavelength).
- The M-shell ($n = 3$) is much further from the nucleus. An M_{α} photon is generated by an electron falling from the N-shell ($n = 4$) to the M-shell.
- Because higher orbital energy levels are spaced very closely together, the energy difference between N and M is very small.
- This incredibly small energy gap generates the lowest energy photon among the options, and therefore the longest wavelength.

Why other options are incorrect:

Options A, B, and C all represent electrons plunging deep into the intensely bound K-shell, releasing highly energetic, short-wavelength X-rays.

Question #10 Key: (D)

SZABMU 2023

Which of following series lies in infra-red region? [SZABMU 2023]

CORE CONCEPT AND DERIVATION

In the hydrogen atom spectrum, the spectral series are strictly classified by the region of the electromagnetic spectrum in which their emitted photons fall, determined by the final resting shell (p).

Formula:

$$p = 1 \rightarrow \text{UV (Lyman)}$$

$$p = 2 \rightarrow \text{Visible (Balmer)}$$

$$p \geq 3 \rightarrow \text{IR (Paschen, Brackett, Pfund)}$$

Solution:

- Lyman is Ultraviolet (UV). Balmer is Visible.
- Paschen ($p = 3$), Brackett ($p = 4$), and Pfund ($p = 5$) all feature low-energy transitions that fall squarely into the Infrared (IR) region.
- Option B correctly pairs two IR series. Option C also correctly pairs two IR series.
- Therefore, Option D accurately encapsulates all correct groupings.

Why other options are incorrect:

Option A is entirely incorrect as it includes UV and Visible series. Options B and C are technically true but functionally incomplete individually compared to the overarching Option D.

Question #11 Key: (C)

DUHS 2023

In which spectral series is the for ultraviolet region of electromagnetic spectrum found? [SINDH 2023]

CORE CONCEPT AND DERIVATION

Ultraviolet radiation comprises high-energy photons. In the hydrogen atom, the highest energy emissions occur when an electron drops back down to the lowest possible energy state, the ground level.

Formula:

$$\Delta E_{\max} = E_n - E_1 \quad (\text{Lyman series})$$

Solution:

- The Lyman series is defined by electronic transitions terminating at the principle quantum shell $p = 1$.
- These jumps (from $n = 2, 3, 4 \dots$ down to $p = 1$) cross the largest energy gaps in the hydrogen atom.
- Because $E = hf$, large energy drops emit high-frequency, high-energy photons, which correspond exactly to the Ultraviolet (UV) spectrum.

Why other options are incorrect:

Balmer (B) falls in the visible range. Paschen (A) and Pfund (D) feature smaller energy transitions terminating at higher energy levels, placing them in the low-energy Infrared region.

Question #12 Key: (B)

DUHS 2023

An atom makes a transition from a state of energy [Formula] to one of lower energy [Formula], which of the fo...

CORE CONCEPT AND DERIVATION

According to Bohr's postulates and the principle of conservation of energy, the energy of an emitted photon exactly equals the energy difference between the initial and final energy states of the atom.

Formula:

$$\Delta E = E_2 - E_1$$

$$E_{\text{photon}} = \frac{hc}{\lambda}$$

Solution:

- Set the transition energy equal to the photon energy:
 $E_2 - E_1 = \frac{hc}{\lambda}$.
- To isolate wavelength (λ), multiply both sides by λ and divide by the energy difference ($E_2 - E_1$).
- This algebraically yields: $\lambda = \frac{hc}{E_2 - E_1}$.

Why other options are incorrect:

Option A is the wave number (inverse wavelength $1/\lambda$). Option C subtracts the higher energy from the lower energy, incorrectly producing a negative wavelength. Option D incorrectly arranges the fundamental constants h and c .

Question #13 Key: (A)

UHS 2022

The speed of electron in the first Bohr orbit is: [UHS 2022]

CORE CONCEPT AND DERIVATION

The orbital velocity of an electron in a hydrogen atom depends on its principal quantum number n . The speed is highest in the first orbit (ground state) and decreases as it moves to higher orbits.

Formula:

$$v_n = \frac{2\pi ke^2}{nh}$$

Solution:

- For the first Bohr orbit of hydrogen, $n = 1$.
- Substitute the known constants: $k = 9 \times 10^9$, $e = 1.6 \times 10^{-19}$ C, and $h = 6.63 \times 10^{-34}$ Js.
- Solving this yields the standard velocity of an electron in the first Bohr orbit: $v_1 \approx 2.18 \times 10^6$ m/s (often rounded to 2.19×10^6 ms⁻¹).

Why other options are incorrect:

Options B, C, and D contain incorrect powers of 10. The speed of the electron in the ground state is a substantial fraction of the speed of light (approx $\frac{c}{137}$), requiring a large positive exponent, not negative or small powers.

Question #14 Key: (C)

SZABMU 2022

Which one of the following series lies in the ultraviolet region? [SZABMU 2022]

CORE CONCEPT AND DERIVATION

The hydrogen emission spectrum is divided into specific series based on the final energy level (p) of the electron transition. Each series corresponds to a distinct region of the electromagnetic spectrum.

Formula:

Lyman ($p = 1$) → Ultraviolet

Balmer ($p = 2$) → Visible

Paschen ($p = 3$) → Infrared

Solution:

- The Lyman series occurs when electrons transition from higher energy levels ($n \geq 2$) down to the ground state ($p = 1$).
- These transitions release the highest amount of energy, corresponding to the shortest wavelengths, which fall strictly in the ultraviolet region.

Why other options are incorrect:

Balmer (A) lies in the visible region. Paschen (B) and Brackett (D) both lie in the infrared region.

Question #15 Key: (D)

SZABMU 2022

Which x-ray photon will have longest wavelength? [SZABMU 2022]

CORE CONCEPT AND DERIVATION

In characteristic X-ray spectra, the wavelength of the emitted photon is inversely proportional to the energy difference between the transitioning electron shells.

Formula:

$$E = \frac{hc}{\lambda} \Rightarrow \lambda \propto \frac{1}{\Delta E}$$

Solution:

- A longer wavelength requires a smaller energy transition (ΔE).
- K-series X-rays result from transitions down to the innermost K shell ($n = 1$), yielding massive energy drops and very short wavelengths.
- The M_α line results from a transition from the N shell ($n = 4$) to the M shell ($n = 3$).
- Because energy levels get much closer together further from the nucleus, the energy difference between N and M is much smaller than any transition ending at K.
- Smallest ΔE results in the longest wavelength λ .

Why other options are incorrect:

Options A, B, and C all terminate at the deeply bound K shell, resulting in high-energy, extremely short-wavelength X-ray photons.

Question #16 Key: (C)

KMU 2022

The radiation emitted by warm blooded animals lies the region of: [ETEA 2022]

CORE CONCEPT AND DERIVATION

All objects with a temperature above absolute zero emit thermal radiation. The peak wavelength of this emission depends entirely on the object's absolute temperature.

Formula:

$$\lambda_{\max} \times T = 2.898 \times 10^{-3} \text{ m} \cdot \text{K} \quad (\text{Wien's Displacement Law})$$

Solution:

- Warm-blooded animals have an average body temperature of about 310 K (37°C).
- Using Wien's Law: $\lambda_{\max} = \frac{2.898 \times 10^{-3}}{310} \approx 9.3 \times 10^{-6} \text{ m}$.
- A wavelength of $9.3 \mu\text{m}$ falls squarely in the mid-infrared region of the electromagnetic spectrum.

Why other options are incorrect:

Animals are not hot enough (like the Sun) to emit primarily in the visible (A) or ultraviolet (B) regions. X-rays (D) require extreme high-energy atomic transitions, completely unrelated to physiological thermal emission.

Question #17 Key: (A)

KMU 2022

The shortest possible wavelength is associated with: [ETEA 2022]

CORE CONCEPT AND DERIVATION

The wavelength of an emitted photon is inversely proportional to the energy transition. The shortest possible wavelength across all series corresponds to the maximum possible energy transition in the hydrogen atom.

Formula:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{p^2} - \frac{1}{n^2} \right)$$

Solution:

- To minimize λ , the expression $\left(\frac{1}{p^2} - \frac{1}{n^2} \right)$ must be maximized.
- This happens when the electron falls to the lowest possible ground state ($p = 1$, the Lyman series) from the highest possible initial state ($n = \infty$).
- This maximum energy gap (13.6 eV) translates to the absolute shortest wavelength in the entire hydrogen spectrum.

Why other options are incorrect:

Balmer, Paschen, and Brackett series end at higher energy levels ($p = 2, 3, 4$), meaning their largest possible energy drops are always smaller than the Lyman series, resulting in strictly longer wavelengths.

Question #18 Key: (A)

KMU 2022

The longest wavelength observed in Balmer series is: [ETEA 2022]

CORE CONCEPT AND DERIVATION

The longest wavelength in any spectral series corresponds to the minimum energy transition. For the Balmer series, this occurs when an electron transitions from $n = 3$ to $p = 2$.

Formula:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{p^2} - \frac{1}{n^2} \right)$$

Solution:

- Substitute $p = 2$ and $n = 3$ into the Rydberg equation:
- $\frac{1}{\lambda} = R_H \left(\frac{1}{2^2} - \frac{1}{3^2} \right)$
- $\frac{1}{\lambda} = R_H \left(\frac{1}{4} - \frac{1}{9} \right) = R_H \left(\frac{9-4}{36} \right) = R_H \left(\frac{5}{36} \right)$
- Invert the result to solve for wavelength: $\lambda = \frac{36}{5R_H}$.

Why other options are incorrect:

The other options result from incorrect fractional subtractions or choosing the wrong series transitions.

Question #19 Key: (B)

KMU 2022

The shortest wavelength of Lyman series is ([Formula]): [ETEA 2022]

CORE CONCEPT AND DERIVATION

The shortest wavelength in the Lyman series corresponds to the transition with the maximum energy. This happens when an electron falls from infinity ($n = \infty$) down to the ground state ($p = 1$).

Formula:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{p^2} - \frac{1}{n^2} \right)$$

Solution:

- Set $p = 1$ (Lyman series) and $n = \infty$ (shortest wavelength limit).
- Substitute into the Rydberg formula: $\frac{1}{\lambda} = R_H \left(\frac{1}{1^2} - \frac{1}{\infty^2} \right)$.
- Since $\frac{1}{\infty^2} = 0$, the equation simplifies strictly to $\frac{1}{\lambda} = R_H(1 - 0) = R_H$.
- Inverting both sides gives $\lambda = \frac{1}{R_H}$.

Why other options are incorrect:

Option A is the wave number ($1/\lambda$), not the wavelength. Options C and D represent calculations for entirely different transitions or incorrect algebraic inversions.

Question #20 Key: (D)

DUHS 2022

If Rydberg constant for hydrogen is [Formula] then wave length ' [Formula] ' of first line in Lyman series is ...

CORE CONCEPT AND DERIVATION

The 'first line' of a series is the lowest energy transition. For the Lyman series (ground state $p = 1$), the first line corresponds to an electron falling from the closest upper level, which is $n = 2$.

Formula:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{p^2} - \frac{1}{n^2} \right)$$

Solution:

- Substitute $p = 1$ and $n = 2$.
- $\frac{1}{\lambda} = R_H \left(\frac{1}{1^2} - \frac{1}{2^2} \right)$
- $\frac{1}{\lambda} = R_H \left(1 - \frac{1}{4} \right) = R_H \left(\frac{3}{4} \right)$
- To find λ , invert the fraction: $\lambda = \frac{4}{3R_H}$.

Why other options are incorrect:

Option A is an incorrect inversion leaving R_H in the numerator. Options B and C represent random algebraic errors or incorrect n values.

Question #21 Key: (B)

DUHS 2022

The kinetic energy of an electron in first Bohr radius of H - atom is: [DUHS 2022]

CORE CONCEPT AND DERIVATION

In the Bohr model, the total energy of an electron in a given orbit is the sum of its kinetic and potential energies. By the Virial theorem for Coulombic forces, Kinetic Energy ($K.E.$) is exactly equal to the negative of the Total Energy ($T.E.$).

Formula:

$$K.E. = -T.E.$$

Solution:

- The total energy of an electron in the first Bohr orbit (ground state, $n = 1$) of hydrogen is -13.6 eV.
- Kinetic energy is a scalar quantity of motion and must always be positive.
- Therefore, $K.E. = -(-13.6 \text{ eV}) = +13.6 \text{ eV}$.

Why other options are incorrect:

Option C (-13.6 eV) represents the *Total Energy*, not kinetic energy. Option A uses the wrong unit (Joules instead of electron-volts). Option D uses incorrect scaling (keV).