# Atomic Physics JEE Main PYQ - 2

**Total Time:** 20 Minute **Total Marks:** 40

## Instructions

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1. Test will auto submit when the Time is up.
2. The Test comprises of multiple choice questions (MCQ) with one or more correct answers.
3. The clock in the top right corner will display the remaining time available for you to complete the examination.

### Navigating & Answering a Question

1. The answer will be saved automatically upon clicking on an option amongst the given choices of answer.
2. To deselect your chosen answer, click on the clear response button.
3. The marking scheme will be displayed for each question on the top right corner of the test window.

# Atomic Physics

1. A $12.5\,eV$ electron beam is used to bombard gaseous hydrogen at room temperature. It will emit : [12-Apr-2023 shift 1] **(+4)**

   a. 2 lines in the Lyman series and 1 line in the Balmar series

   b. 3 lines in the Lyman series

   c. 1 line in the Lyman series and 2 lines in the Balmar series

   d. 3 lines in the Balmer series

---

2. As an electron makes a transition from an excited state to the ground state of a hydrogen- like atom/ion [2015] **(+4)**

   a. kinetic energy, potential energy and total energy decrease

   b. kinetic energy decreases, potential energy increases but total energy remains same

   c. kinetic energy and total energy decrease but potential energy increases

   d. its kinetic energy increases but potential energy and total energy decrease

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3. A hydrogen atom, initially in the ground state is excited by absorbing a photon of wavelength 980$\mathring{A}$. The radius of the atom in the excited state, it terms of Bohr radius $a_0$, will be : $(h_c = 12500\,eV - \mathring{A})$ [29-Jan-2024 Shift 1] **(+4)**

   a. $9a_0$

   b. $25a_0$

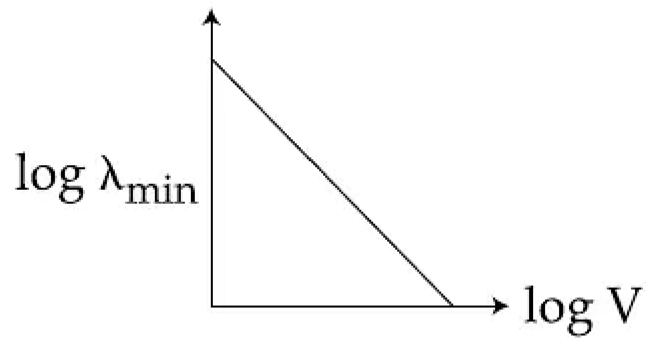
   c. $4a_0$

   d. $16a_0$

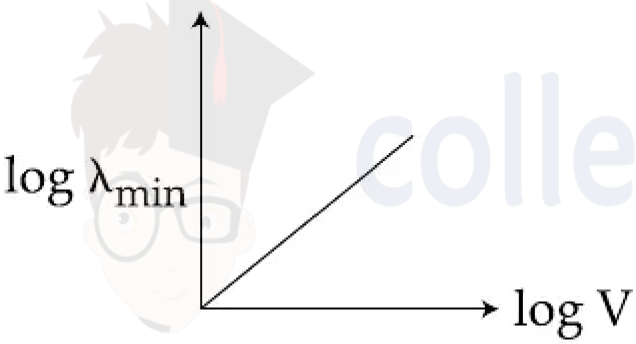
---

**4.** An electron beam is accelerated by a potential difference $V$ to hit a metallic target to produce $X-$rays. It produces continuous as well as characteristic $X$-rays. If $\lambda_{\min}$ is the smallest possible wavelength of $X$-ray in the spectrum, the variation of $\log \lambda_{\min}$ with log $V$ is correctly represented in : **(+4)**

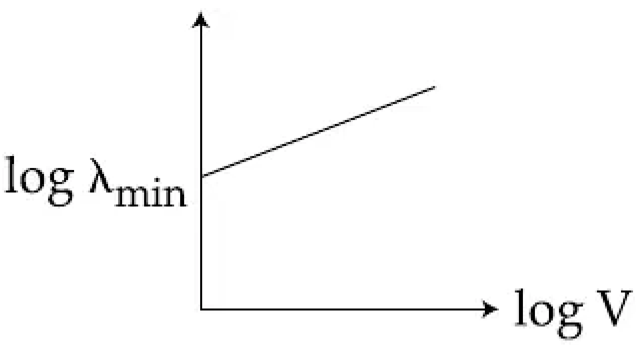
[Online•April•9,•2013]



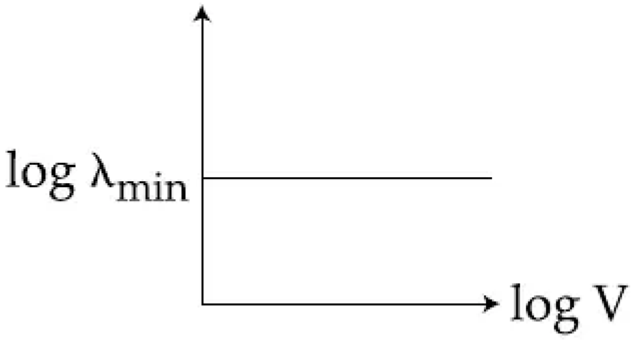

**a.**




**b.**




**c.**

d. 


5. An electron from various excited states of hydrogen atom emit radiation to come to the ground state. Let $\lambda_n, \lambda_g$ be the de Broglie wavelength of the electron in the $n^{th}$ state and the ground state respectively. Let $\Lambda_n$ be the wavelength of the emitted photon in the transition from the $n^{th}$ state to the ground state. For large $n$, $(A, B$ are constants) **(+4)**

[2018]

a. $\Lambda_n \approx A + \frac{B}{\lambda_n^2}$

b. $\Lambda_n \approx A + B\lambda_n$

c. $\Lambda_n^2 \approx A + B\lambda_n^2$

d. $\Lambda_n^2 \approx \lambda$

6. Hydrogen atom from excited state comes to the ground by emitting a photon of wavelength $\lambda$ The value of principal quantum number 'n' of the excited state will be :(R : Rydberg constant) **(+4)**

[25-Jul-2022-Shift-2]

a. $\sqrt{\frac{\lambda R}{\lambda - 1}}$

b. $\sqrt{\frac{\lambda R}{\lambda R - 1}}$

c. $\sqrt{\frac{\lambda}{\lambda R - 1}}$

d. $\sqrt{\frac{\lambda R^2}{\lambda R - 1}}$

7. If the two metals $A$ and $B$ are exposed to radiation of wavelength $350 mm$. The work functions of metals $A$ and $B$ are $4.8 eV$ and $2.2 eV$. Then choose the correct **(+4)**

option [29-Jan-2024 Shift 2]

**a.** Both metals A and B will emit photo-electrons

**b.** Metal B will not emit photo-electrons

**c.** Both metals $A$ and $B$ will not emit photo-electrons

**d.** Metal A will not emit photo-electrons

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**8.** Find out $5^{th}$ orbit radius (in pm) of $Li^{++}$ if ground orbit radius of H-atom is 51 pm. **(+4)**

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**9.** The potential energy of an electron is defined as U = $\frac{1}{2}$ $mw^2x^2$ and follows Bohr's law. Radius of orbit as function of n depends on? (w is same constant) **(+4)**

[30-Jan-2024•Shift•1]

**a.** $n^2$

**b.** $\frac{1}{\sqrt{n}}$

**c.** $\sqrt{n}$

**d.** $n^{\frac{2}{3}}$

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**10.** Find the radius of the orbit corresponding to the 4th excited state in Li++. (a0 is the radius of first orbit in H-atom) **(+4)**

[29-Jul-2022-Shift-1]

**a.** $\frac{25}{3}\,a_0$

**b.** $\frac{16}{3}\,a_0$

**c.** $25\,a_0$

**d.** $12\,a_0$

# Answers

1. **Answer: a**

## Explanation:

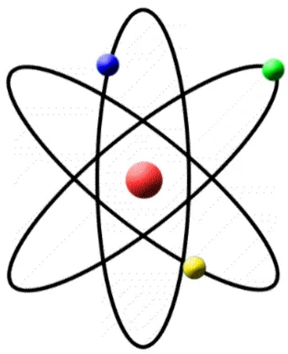
$E = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{E} = \frac{6.62 \times 10^{-34} \times 3 \times 10^{8}}{12.5 \times 1.6 \times 10^{-19}}$
$= 993 A?$
$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2{}^2}\right)$
(where Rydberg constant ,R= 1.097 x $10^7$)
$or, \frac{1}{993 \times 10^{-10}} = 1.097 \times 10^7 \left(\frac{1}{1^2} - \frac{1}{n_2{}^2}\right)$
Solving we get $n_2$ = 3
Spectral lines Total number of spectral lines = 3
Two lines in Lyman series for $n_1 = 1, n_2 = 2$
and $n_1 = 1, n_2 = 3$ and one in Balmer series
for $n_1 = 2, n_2 = 3$

## Concepts:

1. **Atoms:**

- The smallest unit of matter indivisible by chemical means is known as an **atom**.
- The fundamental building block of a chemical **element**.
- The smallest possible unit of an element that still has all the chemical properties of that element.
- An atom is consisting of a nucleus surrounded by one or more shells of **electron s.**
- **Word origin:** from the Greek word *atomos*, which means uncuttable, something that cannot be divided further.

All matter we encounter in everyday life consists of smallest units called atoms – the air we breath consists of a wildly careening crowd of little groups of atoms, my computer's keyboard of a tangle of atom chains, the metal surface it rests on is a crystal lattice of atoms. All the variety of matter consists of less than hundred species of atoms (in other words: less than a hundred different chemical elements).



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2. **Answer: d**

**Explanation:**

$E_{\text{Total}} = -13.6\, eV \frac{Z^2}{n^2}$
$KE = |E_{\text{Total}}|$
$PE = 2\, E_{\text{total}}$
As n decreases, Total energy decreases, potential energy decreases and kinetic energy increases.

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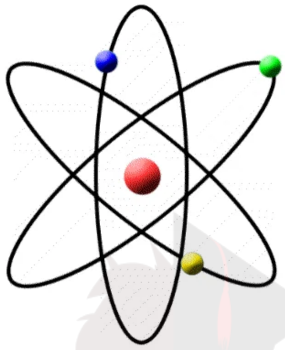

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3. **Answer: d**

   **Explanation:**

The correct answer is (D) : $16a_0$

Energy of photon $= \frac{12500}{980} = 12.75eV$

$\therefore$ Electron will excite to $n = 4$

Since $'R' \propto n^2$

$\therefore$ Radius of atom will be $16a_0$

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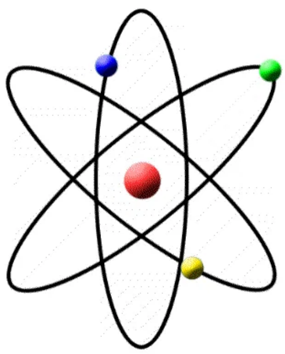

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4. **Answer: a**

### Explanation:

In X-ray tube
$\lambda_{\min} = \frac{hc}{eV}$
In $\lambda_{\min} = In\left(\frac{hc}{e}\right) - InV$
Slope is negative
Intercept on y-axis is positive

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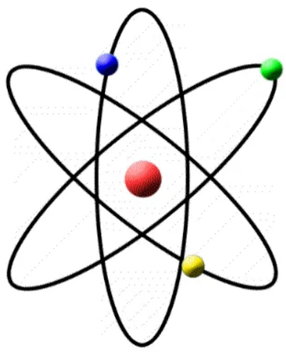

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## 5. Answer: a

### Explanation:

$$P_n = \frac{h}{\lambda_n}, P_g = \frac{h}{\lambda_g}$$
$$k = \frac{P^2}{2m} = \frac{h^2}{2m\lambda^2}, E = -k = -\frac{h^2}{2m\lambda^2}$$
$$E_n = -\frac{h^2}{2m\lambda_n^2}, E_g = -\frac{h^2}{2m\lambda_g^2}$$
$$E_n - E_g = \frac{h^2}{2m}\left(\frac{1}{\lambda_g^2} - \frac{1}{\lambda_n^2}\right) = \frac{hc}{\Lambda_n}$$
$$\frac{h^2}{2m}\left(\frac{\lambda_n^2 - \lambda_g^2}{\lambda_g^2\lambda_n^2}\right) = \frac{hc}{\Lambda_n}$$
$$\Lambda_n = \frac{2mc}{h}\left(\frac{\lambda_g^2\lambda_n^2}{\lambda_n^2 - \lambda_g^2}\right)$$
$$\Lambda_n = \frac{2mc\lambda_g^2}{h}\frac{\lambda_n^2}{\lambda_n^2\left(1 - \frac{\lambda_g^2}{\lambda_n^2}\right)}$$
$$= \frac{2mc\lambda_g^2}{h}\left[1 - \frac{\lambda_g^2}{\lambda_n^2}\right]^{-1}$$
$$= \frac{2mc\lambda_g^2}{h}\left[1 + \frac{\lambda_g^2}{\lambda_n^2}\right]$$

$$= \frac{2mc\lambda_g^2}{h} + \left(\frac{2mc\lambda_g^4}{h}\right)\frac{1}{\lambda_n^2}$$
$$= A + \frac{B}{\lambda_n^2}$$
$$A = \frac{2mc\lambda_g^2}{h}, B = \frac{2mc\lambda_g^4}{h}$$

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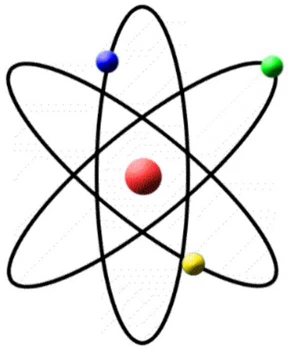

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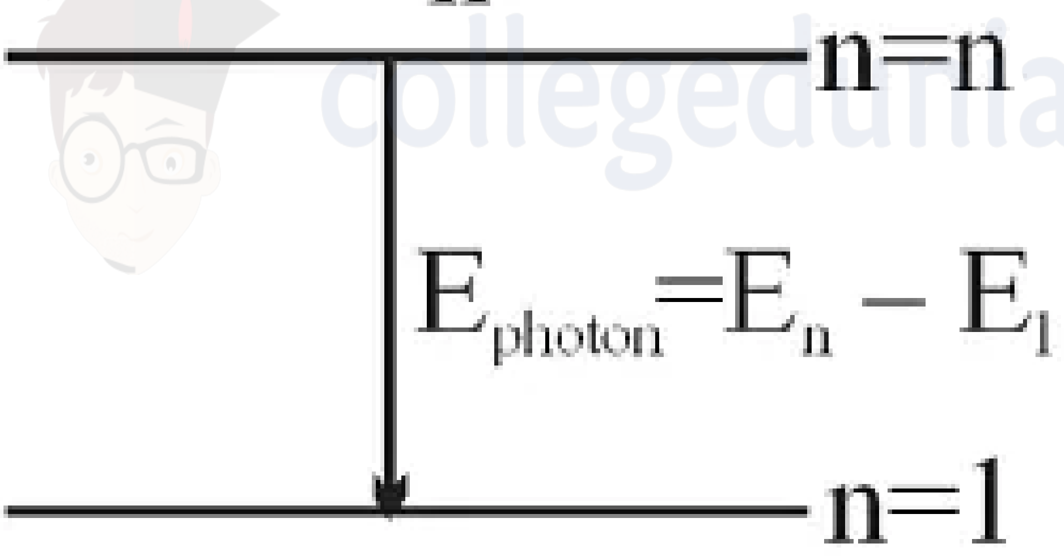
6. **Answer: b**

**Explanation:**

$$E_n = \frac{-Rch}{n^2}(1)$$




$$E_1 = \frac{-Rch}{(1)^2}(1)$$

$$\frac{-Rch}{(n)^2}+\frac{Rch}{1}=\frac{hc}{\lambda}$$
$$\frac{-R}{n^2}+R=\frac{1}{\lambda}$$
$$R-\frac{1}{\lambda}=\frac{R}{n^2}$$
$$\frac{\lambda R-1}{\lambda}=\frac{R}{n^2}$$
$$n^2=\frac{\lambda R}{\lambda R-1}\Rightarrow n=\sqrt{\frac{\lambda R}{\lambda R-1}}$$

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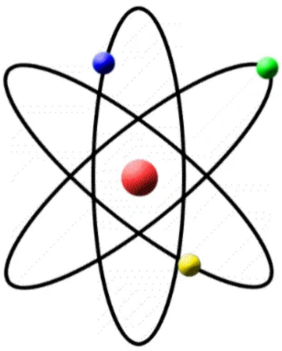

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---

7. **Answer: d**

### Explanation:

The correct answer is (D) : Metal A will not emit photo-electrons


### Concepts:

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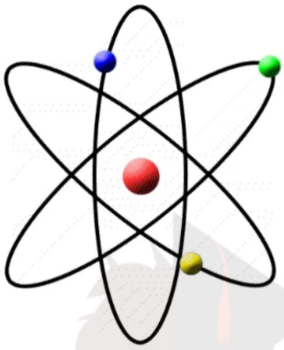

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8. **Answer: 425 - 425**

**Explanation:**

$r_0 = 51pm$
$r = r_0 \times \frac{n^2}{Z}$
$r = 51pm \times \frac{5^2}{3} = 425$

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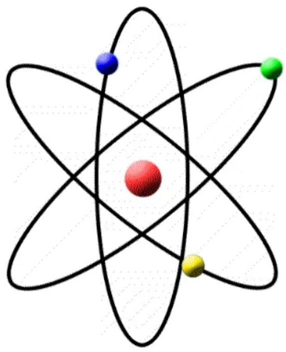

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---

9. **Answer: c**

**Explanation:**

$U = \frac{1}{2}mw^2x^2$

$mvx = \frac{nh}{2\pi}$

$\frac{mv^2}{x} = mw^2x$

$v = wx$

$x^2 \propto n$

$x \propto \sqrt{n}$

So, the correct option is (C): $\sqrt{n}$

**Concepts:**

1. **Bohr's Model of Hydrogen Atom:**

Niels Bohr introduced the atomic Hydrogen model in 1913. He described it as a positively charged nucleus, comprised of protons and neutrons, surrounded by a negatively charged electron cloud. In the model, electrons orbit the nucleus in atomic shells. The atom is held together by electrostatic forces between the positive nucleus and negative surroundings.

**Read More:** Bohr's Model of Hydrogen Atom

## Bohr's Theory of Hydrogen Atom and Hydrogen-like Atoms

A hydrogen-like atom consists of a tiny positively-charged nucleus and an electron revolving around the nucleus in a stable circular orbit.

**Bohr's Radius:**

If 'e,' 'm,' and 'v' be the charge, mass, and velocity of the electron respectively, 'r' be the radius of the orbit, and Z be the atomic number, the equation for the radii of the permitted orbits is given by $r = n^2$ □$r_1$, where 'n' is the principal quantum number, and $r_1$ is the least allowed radius for a hydrogen atom, known as Bohr's radius having a value of 0.53 Å.

## Limitations of the Bohr Model

The Bohr Model was an important step in the development of atomic theory. However, it has several limitations.

1. Bohr's model of the atom failed to explain the Zeeman Effect (effect of magnetic field on the spectra of atoms).
2. It failed to explain the Stark effect (effect of electric field on the spectra of atoms).
3. The spectra obtained from larger atoms weren't explained.
4. It violates the Heisenberg Uncertainty Principle.

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### 10. Answer: a

### Explanation:

The correct answer is option (A): $\frac{25}{3} a_0$

$$r_n = \frac{a_0 n^2}{z}$$

$$= a_0 (\frac{25}{3})$$

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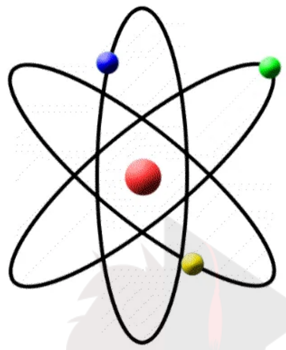

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