Atomic Physics JEE Main PYQ - 1

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. Both the nucleus and the atom of some element are in their respective first excited states. They get de-excited by emitting photons of wavelengths λ_N, λ_A respectively. The ratio $\frac{\lambda_N}{\lambda_A}$ is closest to : **(+4)**

[27•Jul•2021•Shift•2]

a. 10^{-6}

b. 10

c. 10^{-10}

d. 10^{-1}

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2. Consider an electron in a hydrogen atom, revolving in its second excited state (having radius 4.65 ?). The de-Broglie wavelength of this electron is : **(+4)**

[12•April•2019•II]

a. 12.9 ?

b. 3.5 ?

c. 9.7 ?

d. 6.6 ?

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3. In a hydrogen like atom electron makes transition from an energy level with quantum number n to another with quantum number $(n-1). If n >> 1$, the frequency of radiation emitted is proportional to **(+4)**

[11•Jan•2019•II]

a. $\frac{1}{n^3}$

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

c. $\frac{1}{n^2}$

d. $\frac{1}{n^{3/2}}$

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4. In a hydrogen like atom, when an electron jumps from the M - shell to the L - shell, the wavelength of emitted radiation is λ. If an electron jumps from N-shell **(+4)**

to the L-shell, the wavelength of emitted radiation will be :

[2009]

a. $\frac{27}{20}\lambda$

b. $\frac{16}{25}\lambda$

c. $\frac{20}{27}\lambda$

d. $\frac{25}{16}\lambda$

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5. In Li^{++}, electron in first Bohr orbit is excited to a level by a radiation of wavelength λ. when the ion gets deexcited to the ground state in all possible ways (including intermediate emissions), a total of six spectral lines are observed. What is the value of λ ? (Given : $h = 6.63 \times 10^{-34}\ Js; c = 3 \times 10^{8}\ ms^{-1}$) ; **(+4)**

[10 April 2019 II]

a. 9.4 nm

b. 12.3 nm

c. 10.8 nm

d. 11.4 nm

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6. As per the Bohr model, the minimum energy (in eV) required to remove an electron from the ground state of a double ionized Li atom (Z = 3) is [9•April•2019•I] **(+4)**

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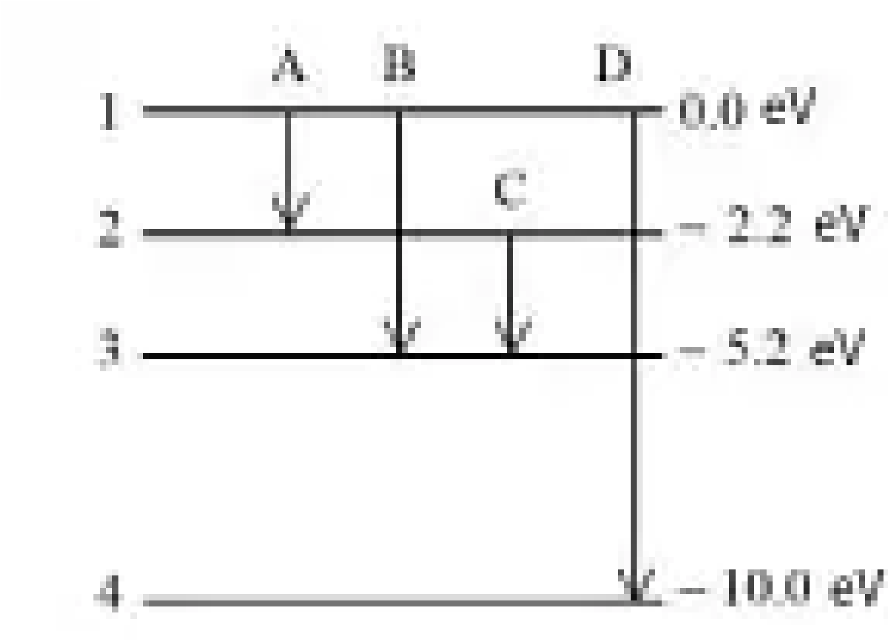
7. The energy levels of an atom is shown in figure: **(+4)**



Which one of these transitions will result in the emission of a photon of wavelength $1241\,nm$? Given $\left(h = 6.62 \times 10^{-34} Js\right)$

[25-Jan-2023•Shift•2]

a. D

b. B

c. A

d. C

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8. Hydrogen atom from excited state comes to the ground by emitting a photon of wavelength λ 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. $\sqrt{\frac{\lambda R^2}{\lambda R - 1}}$

---

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

[25-Jul-2022-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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10. Find out 5th orbit radius (in pm) of Li^{++} if ground orbit radius of H-atom is 51 pm. **(+4)**

[26-Jul-2022-Shift-1]

Answers

1. Answer: a

Explanation:

We know that $E = \frac{hc}{\lambda}$
So, for atom $E_A = \frac{hc}{\lambda_A}$
for neutron $E_N = \frac{hc}{\lambda_N}$
Then, $\frac{E_A}{E_N} = \frac{hc}{\lambda_A} \times \frac{\lambda_N}{hc}$
$\Rightarrow \frac{\lambda_N}{\lambda_A}$
Here, E_A is order of eV and E_N is order of MeV.
Therefore,
$\frac{\lambda_N}{\lambda_A} = \frac{E_A}{E_N} = \frac{eV}{MeV} = \frac{1eV}{10^6 eV}$
$\lambda_N = 10^{-6}\lambda_A$

Concepts:

1. Atoms:

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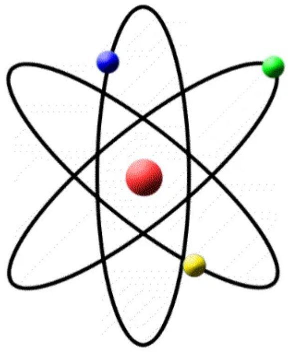

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2. **Answer: c**

Explanation:

$$2\pi r_n = n\lambda_n$$
$$\lambda_3 = \frac{2\pi(4.65\times10^{-10})}{3}$$
$$\lambda_3 = 9.7\,?$$

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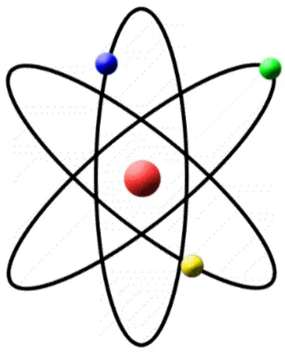

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3. Answer: a

Explanation:

In a hydrogen like atom, when an electron makes an transition from an energy level with n to n - 1, the frequency of emitted radiation is

$$v = RcZ^2\left[\frac{1}{(n-1)^2} - \frac{1}{n^2}\right] = \frac{RcZ^2(2n-1)}{n^2(n-1)^2}$$

As n > > 1

$$\therefore \quad v = \frac{RcZ^2 2N}{n^4} = \frac{2RcZ^2}{n^3} \text{ or } v \propto \frac{1}{n^3}$$

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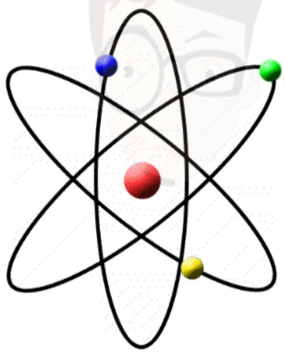

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4. **Answer: c**

Explanation:

For $M \to L$ steel

$\frac{1}{\lambda} = K\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = \frac{K \times 5}{36}$

for $N \to L$

$\frac{1}{\lambda'} = K\left(\frac{1}{2^2} - \frac{1}{4^2}\right) = \frac{K \times 3}{16}$

$\lambda' = \frac{20}{27}\lambda$

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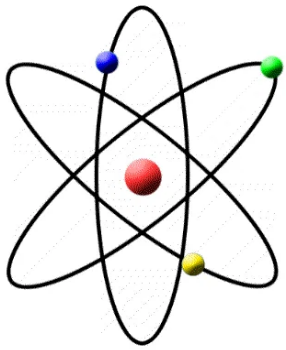

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5. **Answer: c**

Explanation:

$$\Delta E = \frac{hc}{\lambda}$$
$$13.6 \times 9 - 0.85 \times 9 = \frac{hc}{\lambda}$$
$$\lambda = \frac{hc}{9 \times (13.6 - 0.85) eV}$$
$$= \frac{1240 eV.nm}{9 \times 12.75 eV}$$
$$\lambda = 10.8\, nm$$

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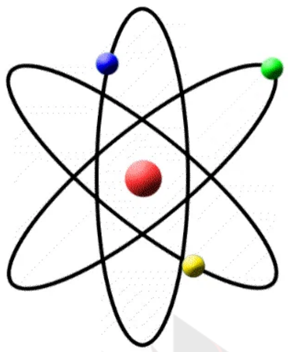

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6. **Answer: -122.4 - -122.4**

Explanation:

Explanation:
Energy of the nth orbit by Bohr was given by:

$$= \quad \times \frac{2}{2}$$

where, = energy = Rydberg's Constant = atomic number = 3 (for lithium) = number of orbit.
Putting the values, in above equation, we get
Energy of the first shell(n=1) in hydrogen atom:
$= 1 - 13.6 \quad = \quad \times \frac{1^2}{1^2}^2 \quad = -13.6$
To find energy value of electron in the excited state of $^{2+}$ is:
$: 1 \ ^2 2 \ ^1 \ ^{2+} : 1 \ ^1 \quad = 3, \quad = 1 \quad = -13.6 \times \frac{3^2}{1^2} \quad = -122.4$
Hence, the correct answer is -122.4.

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 $r = n^2 \times r_1$, 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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7. Answer: a

Explanation:

The correct answer is (A) : D

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

$\Delta E_A = 2.2\, eV$

$\Delta E_B = 5.2\, eV$

$\Delta E_C = 3\, eV$

$\Delta E_D = 10\, eV$

$\lambda_A = \frac{6.62\times10^{-34}\times3\times10^{8}}{2.2\times1.6\times10^{-19}}$

$= \frac{12.41\times10^{-7}}{2.2} m$

$= \frac{1241}{2.2} nm = 564\, nm$

$\lambda_B = \frac{1241}{5.2} nm = 238.65\, nm$

$\lambda_C = \frac{1241}{3} nm = 413.66\, nm$

$\lambda_D = \frac{1241}{10} = 124.1\, nm$

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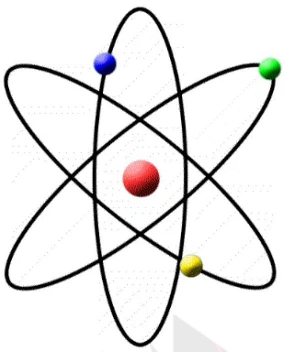

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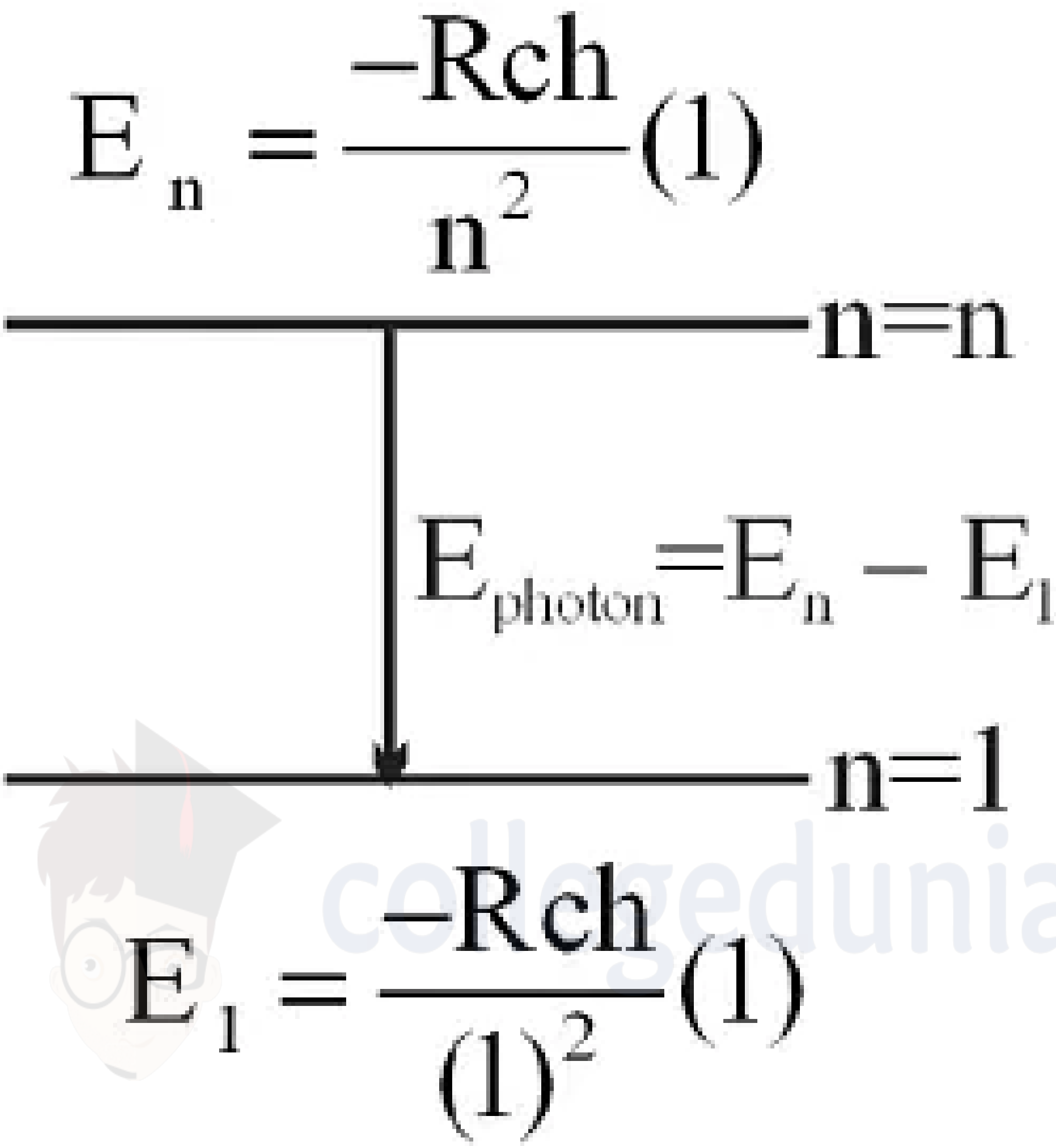
8. **Answer: b**

   Explanation:



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

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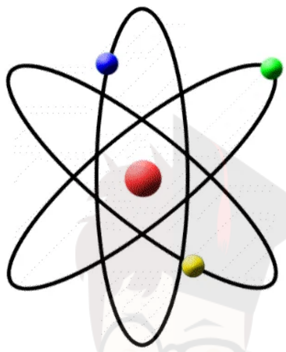

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9. **Answer: d**

Explanation:

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

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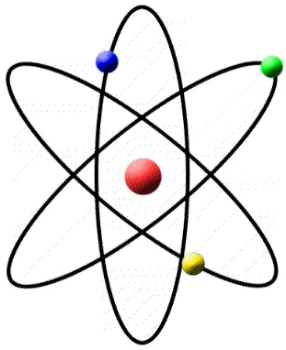

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10. **Answer: 425 - 425**

Explanation:

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

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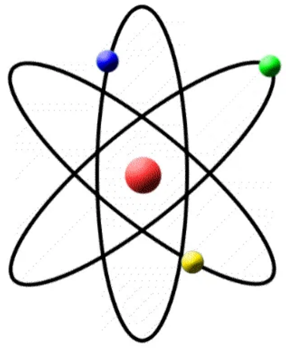

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