PHYSICS

BOOKS - RESNICK AND HALLIDAY PHYSICS (HINGLISH)

HYDROGEN ATOM

Sample Problem

1. An electron is confined to a one - dimensional, infinitely deep potential energy

well of width L = 100 pm. (a) What is the smallest amount of energy the electron can have? (A trapped electron cannot have zero energy.)

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2. How much energy must be transferred to the electron if it is to make a quantum jump from its ground state to its second excited state?

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3. If the electron gains the energy for the jump from energy level E_1 to energy level E_3 by absorbing light, what light wavelength is required ?

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4. Once the electron has been exicted to the second excited state, what wavelengths of light can it emit by de - excitation?

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5. A ground state electron is trapped in the one dimensional infinite potential well of fig. $38-2$, with width L = 100 pm.

(a) What is the probability that the electron can be detected in the left one third of well $(x_1 = 0 \text{ to } x_2 = L/3)$

What is the probability that the electron can be detected in the middle one third of the well?

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6. Evaluate the amplitude constant A in Eq. 38-10 for an infinite potential well extending from $x = 0$ to $x = L$.

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7. What is the wavelength of ligth for the least energetic photon emitted in the Lyman series of the hydrogen spectrum. (Take , hc =1240 eV - nm)

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8. What is the wavelength of the series limit for the Lyman series ?

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9. A neutron moving with a speed v strikes a hydrogen atom in the ground state moving toward it with the same speed. Find the minimum kinetic energy of the neutron for which inelastic (completely or partially) collision might take place. $(\text{Take } m_a = m_b.)$

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10. Consider an excited hydrogen atom in state n moving with a velocity $v(v < < c)$. It emits a photon in the direction of its motion and changes its state to a lower state m. Apply momentum and energy conservation principle to calculate the frequency v of the

emitted radiation, compare this with the frequency v_0 emitted if the atom were at rest.

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11. A muon is unstable elementary particle wohse mass is $207m_e$ and whose charge is either $+e$ or $-e$. A negative moun (μ^-) can be captured by a proton to form a muonic atom. (a) Find the distance between the moun and proton for this atom. (b) Find the ionization energy of the atom.

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12. Show that the radial probability density for the ground state of the hydrogen atom has maximum at r = a.

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13. It can be shown that probability p(r) that the electron in the ground state of the hydrogen atom will be detected inside a sphere of radius R is given by

$$p(r) = 1 - e^{-2x}(1 + 2x + 2x^2).$$

in which x, a dimensionless quantity, is equal to r/a. Find r for $p(r) = 0.90$.

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Checkpoint

1. Rank the following pairs of quantum states for an electron confined to an infinite well according to the energy differences between the states, greatest first : (a) n = 3 and, (b) n = 5 and n = 4, (c) n = 4 an n = 3.

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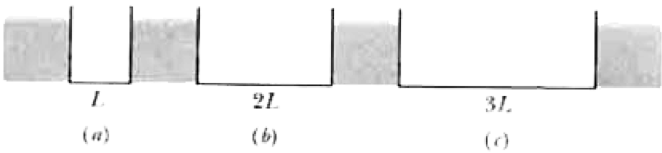
2. The figure shows three infinite potential wells of widths $L, 2L, \text{ and } 3L$, each contains an electron in the state for which n = 10. Rank the wells according to (a) the number of maxima for the probability density of the electron and (b) the energy of the electron, greatest first.



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3. Each of the following particles is confined to an infinite well, and all four wells have the same width : (a) an electron, (b) a proton, (c) a deuteron, and (d) and alpha particle. Rank their zero - point energies, greatest first. The particles are listed in order of increasing mass.

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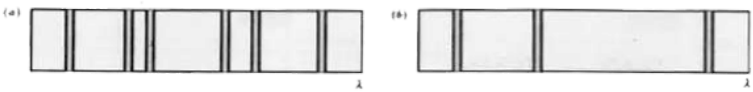
4. In the following figure, one of the spectra is emission spectra and other is absorption spectra of the same element. Identify which is which?



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5. What would be the effect of nuclear motion on the radius of the electronic orbit? Would the radius be the same as that of the predicted Bohr orbit By Eq. more or less?

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6. (a) A group of quantum states of the hydrogen atom has n= 5. How many values of l are possible for states in the group? (b) A subgroup of hydrogen atom states in the n = 5 group has l = 3. How many values of m_l are possible for states in this subgroup?

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Problems

1. An atom (not a hydrogen atom) absorbs a photon whose associated wavelength is 400 nm and then immediately emits a photon whose associated wavelength is 580 nm. How much net energy is absorbed by the atom in this process?

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2. Calculate the radial probability density P(r) for the hydro- gen atom in its ground state at (a) r = 0, (b) r = a, and (c) r= 2a, where a is the Bohr radius.

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3. What is the ratio of shortest wavelength of the Balmer series ot the shortest waelength of the Lyman series?

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4. A neutron with a kinetic energy of 6.0 eV collides with a stationary hydrogen atom in its ground state. Explain why the collision must be elastic-that is, why kinetic energy must be conserved. (Hint: Show that the hydrogen atom cannot be excited as a result of the collision.)

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5. An atom (not a hydrogen atom) absorbs a photon whose associated frequency is $5.6xx10^{14}$ Hz. By what amount does the energy of the atom increase?

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6. What is the probability that an electron in the ground state of the hydrogen atom will be found between two spherical shells whose radii are r and $r + \Delta r$, (a) if r = 0.500a and Δr = 0.010a and (b) if r = 1.00a and Δr = 0.01a, where a is the Bohr radius? (Hint: Δr is small enough to permit the radial probability density to be taken to be constant between r and $r + \Delta r$.)

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7. In the ground state of the hydrogen atom, the electron has a total energy of -13.6 eV. What are (a) its kinetic energy and (b) its potential energy if the electron is one Bohr radius from the central nucleus?

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8. A hydrogen atom, initially at rest in the n = 3 quantum state, undergoes a transition to the ground state, emitting a photon in the process. What is the speed of the recoiling hydrogen atom?

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9. How much work must be done to pull apart the electron and the proton that make up the hydrogen atom if the atom is initially in (a) its ground state and (b) the state with $n = 2$?

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10. An electron is in a certain energy state in a one- dimensional, infinite potential well from x = 0 to x = L = 180 pm. The electron's probability density is zero at x = 0.300L, and x = 0.400L, it is not zero at intermediate values of x. The electron then jumps to the next lower energy level by emitting light. What is the change in the electron's energy?

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11. Monochromatic radiation of wavelength λ is incident on a hydrogen sample in ground state. Hydrogen atoms absorb a fraction of light and subsequently emit radiations of six different wavelength . Find the wavelength λ.

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12. How much energy is required to cause an electron of hydrogen to move from n = 1 state to n = 2 state?

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13. A particle is confined to the one-dimensional infinite potential well of Fig. 38-2. If the particle is in its ground state, what is its probability of detection between (a) x = 0 and x 0.25L, (b) x =0.75L and x = L, and (c) x = 0.25L and x 0.75L?

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14. For the hydrogen atom in its ground state, calculate (a) the probability density y (r) and (b) the radial probability density $\Psi^2(r)$ for r= a, where a is the Bohr radius.

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15. Light of wavelength 102.6 nm is emitted by a hydrogen atom. What are the (a) higher quantum number and (b) lower quantum number of the transition producing this emission? (c) What is the name of the series that includes the transition?

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16. What are the (a) energy. (b) magnitude of the momentum, and (c) wavelength of the photon emitted when a hydrogen atom undergoes a transition from a state with $n = 3$ to a state with $n = 1$?

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17. What are the (a) wavelength range and (b) frequency range of the Lyman series? What are the (c) wavelength range and (d) frequency range of the Balmer series?

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18. An electron is trapped in a one-dimensional infinite potential well. For what (a) higher quantum number and (b) lower quantum number is the corresponding energy difference equal to the energy of the n= 5 level? (c) Show that no pair of adjacent levels has an energy difference equal to the energy of the n =6 level.

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19. Suppose that a hydrogen atom in the ground state absorbs photons of wavelength 15 nm. (a) Will the atom be ionized? (b) If so, what will be the kinetic energy of the electron when it gets far away from its atom of origin?

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20. A proton is confined to a one-dimensional infinite potential well 120 pm wide. What is its ground-state energy?

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21. An electron is trapped in a one-dimensional infinite potential well. For what (a) higher quantum number and (b) lower quantum number is the corresponding energy difference equal to the energy diflerence ΔF_{43}

between levels n = 4 and n = 3? (c) Show that no pair of adjacent levels has an energy difference equal to $2\Delta E_{43}$.

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22. For what value of the principal quantum number n would the effective radius, as shown in a probability density dot plot for the hydrogen atom, be 1.0 mm? Assume that has its maximum value of n-1. (Hint: See Fig. 38-19.)

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23. A hydrogen atom is excited from its ground state to the state with $n = 4$. (a) How much energy must be absorbed by the atom? Consider the photon energies that can be emitted by the atom as it de-excites to the ground state in the several possible ways. (b) How many different energies are possible, what are the (c) highest, (d) second highest, (e) third highest, (f) lowest, (g) second lowest, and (h) third lowest energies?

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24. An electron is trapped in a one-dimensional infinite potential well that is 100 pm wide, the electron is in its ground state. What is the probability that you can detect the electron in an interval of width Δr 5.0 pm centered at x = (a) 25 pm, (b) 50 pm, and (c) 90 pm? (Hint: The interval Δr is so narrow that you can take the probability density to be constant within it.)

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25. An electron in a one-dimensional infinite potential well of length L has ground-state energy E_1. The length is changed to L' so that the new ground-state energy is $E'_1 = 0.500E_1$. What is the ratio L' / L?

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26. Consider an atomic nucleus to be equivalent to a one- dimensional infinite potential well with $L = 1.4 \times 10^{-14}m$, a typical nuclear diameter. What would be the ground-state energy of an electron if it were trapped in such a potential well? (Note: Nuclei do not contain electrons.)

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27. (a) What is the energy E of the hydrogen-atom electron whose probability density is represented by the dot plot of Fig. 38-16? (b) What minimum energy is needed to remove this electron from the atom?

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28. What is the ground-state energy of (a) an electron and (b) a proton if each is trapped in a one-dimensional infinite potential well that is 300 pm wide?

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29. What must be the width of a one-dimensional infinite potential well if an electron trapped in it in the n =3 state is to have an energy of 4.7 eV?

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30. An electron is trapped in a one-dimensional infinite well of width 200 pm and is in its ground state. What are the (a) longest, (b) second longest, and (c) third longest wavelengths of light that can excite the electron from the ground state via a single photon absorption?

31. Hydrogen atoms are in an excited state with n = 5. In terms of the Bohr's model, (a) how many spectral lines can be radiated as these atoms return to be ground state? (b) Find the energies of the line with the longest and shortest wavelengths.

32. Calculate the smallest kinetic energy which an electron may have and still excite a hydrogen atom initially at rest. What minimum kinetic energy is necessary to ionize the hydrogen atom?

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33. Using the Bohr model, (a) calculate the speed of the electrons in a hydrogen atom in n =1, 2, and 3 level and (b) calculate the orbital period in each of these levels.

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34. Average lifetime of a hydrogen atom excited to n = 2 state is 10^{-8}s. Find the number of revolutions made by the electron on the average before it jumps to the ground state.

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35. The energy needed to detach the electron of a hydrogen like ion in ground state is a system(a) what is the wavelength of the radiation emitted when the electron jumps from the first excited state to the ground state? (b) What is the radius of the orbit for this atom?

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36. A beam of electrons bombards a sample of hydrogen. Through what potential difference must the electron have been accelerated if the first line of the Balmer series is to be emitted?

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Practice Questions Single Correct Choice Type

1. If $\lambda_1 =$ and λ_2 are the wavelengths of the first members of Lyman and Paschen series respectively, then $\lambda_1 : \lambda_2$, is

A. $1:3$

B. $1:30$

C. $7:50$

D. $7:108$

Answer: D

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2. A hydrogen atom of mass m emits a photon corresponding to the fourth line of Brackett series and recoils. If R is the Rydberg's constant and h is the Planck's constant, then recoiling velocity is

A. $\frac{3Rh}{36m}$

B. $\frac{3Rh}{64m}$

C. $\frac{7Rh}{120m}$

D. $\frac{7Rh}{3m}$

Answer: B

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3. In Bohr's model of hydrogen atom, let PE represents potential energy and TE the total energy. In going to a higher level

A. PE decreases, TE increases

B. PE increases, TE increases

C. PE decreases, TE decreases

D. PE increases, TE decreases

Answer: B

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4. In hydrogen atom which quantity is integral multiple of $\frac{h}{2\pi}$

A. Angular momentum

B. Angular velocity

C. Angular acceleration

D. Momentum

Answer: A

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5. The ratio of longest wavelength and the shortest wavelength observed in the five spectral series of emission spectrum of hydrogen is

A. $\frac{4}{3}$

B. $\frac{525}{376}$

C. 25

D. $\frac{900}{11}$

Answer: C

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6. What should be the ratio of minimum to maximum wavelength of radiation emitted by transition of an electron to ground state of Bohr's hydrogen atom ?

A. $\frac{3}{4}$

B. $\frac{8}{9}$

C. $\frac{9}{8}$

D. $\frac{24}{25}$

Answer: A

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7. The frequency f of certain line of the Lyman series of the atomic spectrum of hydrogen satisfies the following conditions: (i) it is the sum of the frequencies of another Lyman line and a Balmer line, (ii) it is the sum of the frequencies of a Lyman line, a Balmer line and a Paschen line, (iii) it is the sum of the frequencies of a Lyman and a Paschen line but no Brackett line. To what transition does f correspond?

A. $n_2 = 3 \to n_1 = 1$

B. $n_2 = 3 \to n_1 = 2$

C. $n_2 = 2 \to n_1 = 1$

D. $n_2 = 4 \to n_1 = 1$

Answer: D

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8. The radius of the Bohr orbit in the ground state of hydrogen atom is 0.5 Å. The radius of the orbit of the electron in the third excited state of He will be

A. 8 Å

B. 4 Å

C. 0.5 Å

D. 0.25 Å

Answer: B

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9. The extreme wavelengths of Paschen series are

A. $0.365\mu m$ and 0.565 mum`

B. $0.818\mu m \text{ and } 1.89\mu m$

C. $1.45\mu m \text{ and } 4.04\mu m$

D. $2.27\mu m \text{ and } 7.43\mu m$

Answer: D

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10. The wavelength or radiations emitted is λ_0 when an electron in hydrogen atom jumps from the third orbit to second. If in the H-atom itself, the electron jumps from fourth orbit to second orbit, the wavelength of emitted radiation will be

A. $\frac{20}{27}\lambda_0$

B. $\frac{16}{25}\lambda_0$

C. $\frac{27}{20}\lambda_0$

D. $\frac{29}{16}\lambda_0$

Answer: A

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11. In hydrogen atom, if the difference in the energy of the electron in n =2 and n=3 orbits is E, the ionization energy of hydrogen atom is

A. 13.2E

B. 7.2E

C. 5.6E

D. 3.2E

Answer: B

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12. Which of the following is true?

A. Lyman series is a continuous spectrum

B. Paschen series is a line spectrum in the infrared

C. Balmer series is a line spectrum in the ultraviolet

D. The spectral series formula can be derived from the Rutherford model of the hydrogen atom

Answer: B

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13. According to Bohr's theory, the variation of perimeter(s) of the electronic orbit with the order of orbit (n) in a particular atom is

A. Linear

B. Parabolic

C. Exponential

D. Rectangular hyperbolic

Answer: B

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14. An excited state of H atom emits a photon of wavelength λ and returns in the ground state. The principal quantum number of excited state is given by:

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15. If the shortest wavelength of Lyman series of hydrogen atom is x, then the wavelength of first member of Balmer series of hydrogen atom will be

A. $9x / 5$

B. $36x / 5$

C. $5x/9$

D. $5x/36$

Answer: B

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16. A particle in a box has quantum states with energies $E = E_0 n^2$, with n = 1, 2, 3, 4, . . . and E_0 =1 eV. Which of these photons could in principle be absorbed?

A. 1eV

B. 2 eV

C. 4 eV

D. 5 eV

Answer: D

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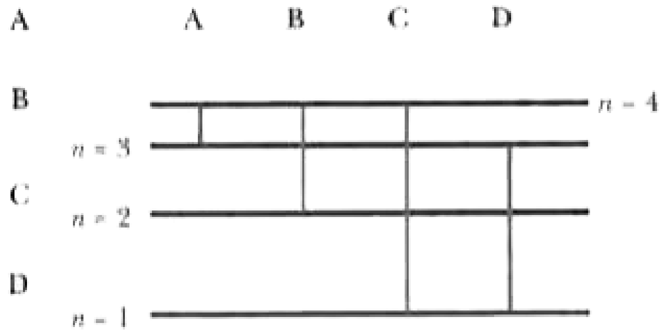
17. Which of the following transitions produce the longest wavelength photon (as shown in the following figure)?



A. $n = 4 \rightarrow 3$

B. $n = 4 \rightarrow 2$

C. $n = 3 \rightarrow 1$

D. $n = 3 \rightarrow 2$

Answer: A

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18. For a quantum particle in a box, the lowest energy quantum state has $1/2$ of the particle de Broglie wave fitting in the box. The next highest state corresponds to

A. $1/4$ de Broglie wavelength

B. $1/2$ de Broglie wavelength

C. 1 de Broglie wavelength

D. 2 de Broglie wavelength

Answer: C

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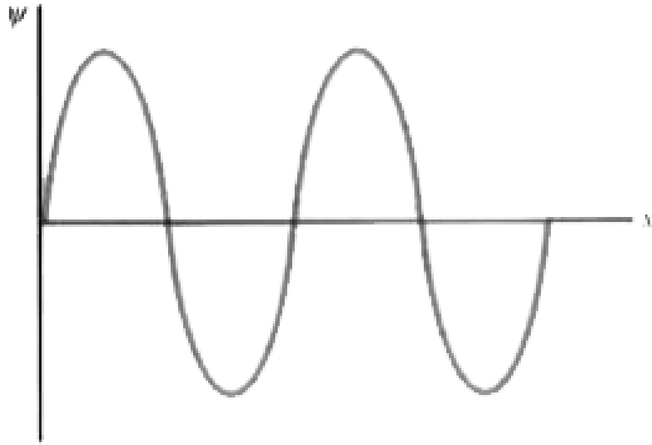
19. An electron is in a one-dimensional trap with zero potential energy in the interior and infinite potential energy at the walls. A graph of its wave function y(x) versus x is shown in the following figure. The value of quantum number n is



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20. A particle is trapped in an infinite potential energy well. It is in the state with quantum number n = 14. How many nodes does the probability density have (counting the nodes at the ends of the well)?

A. None

B. 7

C. 13

D. 15

Answer: D

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21. A particle is confined to a one-dimensional trap by infinite potential energy walls. Of the following states, designed by the quantum number n, for which one is the probability density greatest near the center of the well?

A. n=2

B. n=3

C. n=4

D. n=5

Answer: B

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22. In the Bohr model of hydrogen, why is the atom 9 times larger in the n = 3 state than in the ground state?

A. The electrons are moving 9 times slower

B. The de Broglie wavelength is 9 times longer

C. There are 9 times as many wavelengths in the orbit

D. The de Broglie wavelength is 3 times longer, and there are 3 times as many wavelengths

Answer: D

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23. Orbital electrons do not spiral into the nucleus because of

A. Electromagnetic forces

B. Angular momentum conservation

C. The large nuclear size compared to the electron's size

D. The wave nature of the electron

Answer: D

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24. Bohr's model cannot explain the spectrum of neutral Lithium atoms because

A. Lithium has neutrons in its nucleus

B. Lithium has 3 protons in its nucleus

C. Each lithium atom has more than one electron

D. Neutral lithium atoms have no spectral lines at all

Answer: C

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25. Compared to hydrogen the atom of helium has

A. More mass and is larger in size

B. More mass and is about the same in size

C. More mass and is smaller in size

D. None of the above

Answer: B

26. If the value of Planck's constant were to increase by a factor of two, the size of a hydrogen atom would

A. Decrease by a factor of 4

B. Decrease by a factor of 2

C. Increase by a factor of 2

D. Increase by a factor of 4

Answer: D

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27. In the Bohr model, if an electron moves in an orbit of greater radius

A. Its total energy increases but its kinetic energy decreases

B. Its total energy decreases but its kinetic energy increases

C. Its total energy as well as its kinetic energy decreases

D. Its total energy as well as its kinetic energy increascs

Answer: A

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28. Which of the following statements is (are) wrong for hydrogen atom?

A. The rotational frequency of an electron in an orbit of radius r proportional to the cube of the radius of the orbit

B. The linear momentum of the revolving electron is inversely proportional to the square root of the radius of the orbit

C. The total energy of the system is inversely proportional to the radius of the orbit

D. The magnetic moment of the electron is proportional to square of the radius of the orbit

Answer: A

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29. The total energy of an electron in the excited state corresponding to n =3 state is E. What is its potential energy with proper sign?

A. -2E

B. 2E

C. -E

D. E

Answer: B

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30. Identify the highest energy photons of the following

A. Industrial strength microwave cookers

B. High power AM radio transmitters that cover thousands of square miles

C. Waves from atomic electron transitions among outer orbits

D. Waves from atomic transitions to inner orbits

Answer: D

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31. An atom consists of theree energy levels given by a ground state with energy $E_0 = 0$, the first excited state with energy $E_1 = K$ and the second excited state with energy $E_2 = 2K$ where $K > 0$. The atom is initially in the ground state. Light from a laser which emits photons with energy $1.5K$ is shined on the atom. Which of the following is / are correct?

A. Two photons are absorbed, putting one atom in a state E_1 and one atom in a state E_2

B. A photon will always be absorbed, but half the time the atom will go into the state will energy e and the other half into the state with energy 2e. In this way energy will be conserved on the average

C. The atom absorbs a photon, goes into the first excited state with energy e, and emits a photon with energy 0.5e to conserve energy

D. The atom does not absorb any photons and stays in the ground state

Answer: A

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32. When radiation with a continuous spectrum is passed through a volume of hydrogen gas whose atoms are all in the ground state, which spectral series will be present in the resulting absorption spectrum?

A. Lyman

B. Balmer

C. Paschen

D. Brackett

Answer: A

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33. Which of the following statement is correct in connection with hydrogen spectrum

A. The longest wavelength in the Balmer series is longer than the longest wavelength in Lyman series

B. The shortest wavelength in the Balmer series is shorter than the shortest wavelength in the Lyman series

C. The longest wavelength in both Balmer and Lyman series is equal

D. The longest wavelength in Balmer series is shorter than the longest wavelength in the Lyman series

Answer: A

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34. A hydrogen atom is excited up to 9th level. The total number of possible spectral lines emitted by the hydrogen atom is

A. 36

B. 35

C. 37

D. 38

Answer: a

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35. A hydrogen atom makes a transition from $n = 2$ to $n = 1$ and emits a photon. This photon strikes a doubly ionized lithium atom $(Z = 3)$ in excited state and completely removes the orbiting electron. The least quantum number for the excited stated of the ion for the process is:

A. 2

B. 5

C. 3

D. 4

Answer: d

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36. In a sample of hydrogen-like atom all of which are in ground state, a photon beam containing photos of various energies is passed. In absorption spectrum, five dark lines, are observed. The number of bright lines in the emission spectrum will be (assume that all transitions takes place).

A. 5

B. 10

C. 15

D. None of these

Answer: c

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37. At some place in universe an atom consists of a positron revolving round an antiproton. The ratio of the wavelength of the corresponding spectral lines from this atom and ordinary hydrogen atoms is

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38. A hydrogen atom in its ground state absorbs 10.2 eV of energy. What is the increase in its orbital angular momentum ? S

A. 1×10^{-34}

B. 2×10^{-34}

C. 0.5×10^{-34}

D. Cannot be determined

Answer: A

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39. An electron with kinetic energy =E eV collides with a hydrogen atom in the ground state. The collision will be elastic

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40. Consider the following:

(i) The probability density for an l = 0 state

(ii) The probability density for a state with l = 0

(iii) The average of the probability densities for all states in an l = 0 subshell

Of these, which are spherically symmetric?

A. Only (i)

B. Only (ii)

C. Only (i) and (ii)

D. Only (i) and (iii)

Answer: D

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41. If P(r) is the radial probability density for a hydrogen atom then the probability that the separation of the electron and proton is between r and r+ dr is

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42. Which of the following sets of quantum number is not possible for an electron?

A. n=4,l=3, $m_1 = -3$

B. n = 4,l = 4, $m_1 = -2$

C. n=5,l=-1, m_1 = 2

D. n= 3,l = 1,$m_1 = -2$

Answer: A

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43. Which one of the following pairs of characteristics of light is best explained by assuming that light can be described in terms of photons?

A. Photoelectric effect and the effect observed in Young's experiment

B. Diffraction and the formation of atomic spectra

C. Polarization and the photoelectric effect

D. Existence of line spectra and the photoelectric effect

Answer: D

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44. Complete the following statement: For the ground state of the hydrogen atom, the Bohr model correctly predicts

A. Only the energy

B. Only the angular momentum

C. Only the angular momentum and the spin

D. The angular momentum and the energy

Answer: A

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45. Which one of the following will result in an electron transition from the n = 4 level to the n= 7 level in a hydrogen atom?

A. Emission of a 0.28 eV photon

B. Absorption of a 0.28 eV photon

C. Emission of a 0.57 eV photon

D. Absorption of a 0.57 eV photon

Answer: D

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46. Determine the wavelength of incident electromagnetic radiation required to cause an electron transition from the n = 6 to the n=8 level in a hydrogen atom.

A. 1.2×10^3 nm

B. 7.5×10^3 nm

C. 2.2×10^3 nm

D. 5.9×10^3 nm

Answer: B

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47. The kinetic energy of the ground state electron in hydro- gen is $+13.6$ eV. What is its potential energy?

A. -13.6 eV

B. -27.2 eV

C. $+27.2$ eV

D. $+56.2$ eV

Answer: B

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48. Determine the kinetic energy of an electron that has a de Broglie wavelength equal to twice the diameter of the hydrogen atom. Assume that the hydrogen atom is a sphere of radius 5.3×10^{-11} m.

A. 13.6 eV

B. 33.6 eV

C. 27.2 eV

D. 48.9 eV

Answer: B

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49. According to the quantum mechanical picture of the atom, which one of the following statements is true concerning the magnitude of the angular momentum L of an electron in the n=3 level of the hydrogen atom?

A. L is 0.318h

B. L could be 0.225h or 0.276h

C. L is 0.477h

D. L could be 0.225h or 0.390h

Answer: D

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50. Which quantum number is sufficient to describe the electron in hydrogen atom?

A. n=1

B. n= 3

C. n=2

D. n = 4

Answer: A

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51. How many electron states (including spin states) are possible in a hydrogen atom if its energy is -3.4 eV?

A. 2

B. 6

C. 4

D. 8

Answer: d

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Practice Questions More Than One Correct Choice Type

1. An electron is revolving around a nucleus of hydrogen atom in the first orbit. The radius of this orbit is 0.53 A. Choose the correct option(s)

A. The radius of the first orbit of hydrogen-like atom He^{+} is 1.06Å

B. The radius of the first orbit of hydrogen-like atom He^{+} is0.265Å

C. The energy of the electron of hydrogen-like atom He^{+} in the first orbit is $-13eV$

D. The energy of the electron of hydrogen-like atom He^{+} in the first orbit is -54.4 eV

Answer: B::D

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2. According to Bohr's theory, hydrogen atom for an electron in the nth permissible orbit

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3. In an electron transition inside a hydrogen atom, orbital angular momentum may change by

A. h

B. h/π

C. $h/2\pi$

D. $h/4\pi$

Answer: B::C

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4. Whenever a hydrogen atom emits a photon in the Balmer series

A. It may emit another photon in Balmer series

B. It must emit another photon in Lyman series

C. The second photon, if emitted, will have a wavelength of about 122 nm

D. It may emit a second photon, but the wavelength of this photon cannot be predicted

Answer: B::C

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5. An electron is excited from a lower energy state to a higher energy state in a hydrogen atom. Which of the following quantity/quantities decreases/decrease in the excitation ?

A. Potential energy

B. Angular speed

C. Kinetic energy

D. Angular momentum

Answer: B::C

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6. An electron in hydrogen atom first jumps from second excited state to first excited state and then from first excited state to ground state. Let the ratio of wavelength, momentum and energy of photons emitted in these two cases be a, b and c respectively, Then

A. $c = 1/a$

B. $a = 9/4$

C. $b = 5/27$

D. `c = 5//27

Answer: A::C::D

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7. A neutron collies head-on with a stationary hydrogen atom in ground state. Which of the following statements is/are correct ?

A. If kinetic energy of the neutron is less than 20.4 eV, collision must be elastic.

B. If kinetic energy of the neutron is less than 20.4 eV, collision may be inelastic.

C. Inelastic collision may be take place only when initial kinetic energy of neutron is greater than 20.4 eV.

D. Perfectly inelastic collision cannot take place.

Answer: A::C::D

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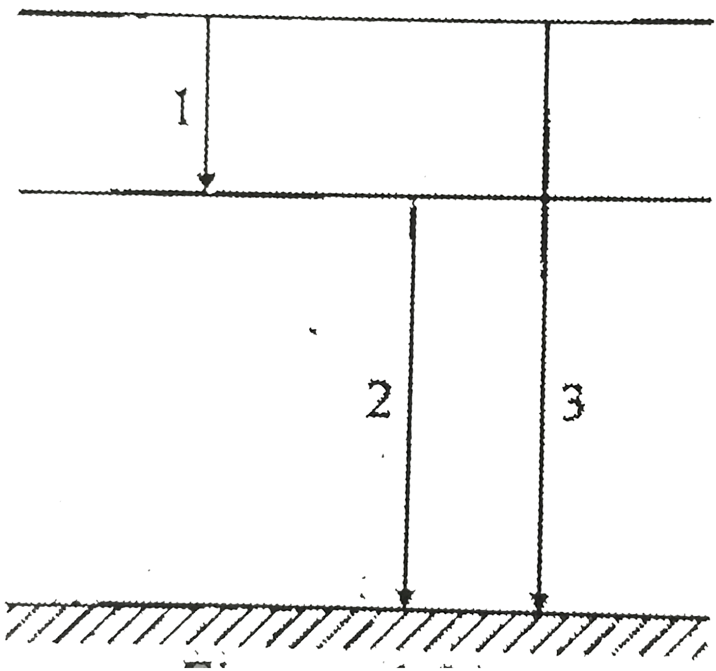
8. The wavelengths and frequencies of photons in transition 1,2 and 3 for hydrogen like atom are $\lambda_1, \lambda_2, \lambda_3, v_1, v_2$ and v_3 respectively. Then:



A. $v_3 = v_1 + v_2$

B. $v_3 = \dfrac{v_1 v_2}{v_1 + v_2}$

C. $\lambda_3 = \lambda_1 + \lambda_2$

D. $\lambda_3 = \dfrac{\lambda_1 \lambda_2}{\lambda_1 + \lambda_2}$

Answer: A::D

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9. A particular hydrogen like atom has its ground state Binding energy $= 122.4 eV$. It is in ground state. Then

A. Its atomic number is 3

B. An electron of 90 eV can excite it

C. An electron of kinetic energy nearly 91.8 eV can be brought to almost rest by this atom

D. An electron of kinetic energy 2.6 eV may emerge from the atom when electron of kinetic energy 125 eV collides with this atom

Answer: A::C::D

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10. In the Bohr model of the hydrogen atom, let R, v and E represent the radius of the orbit, the speed of electron and the total energy of the electron respectively. Which of the following quantity is proportional to the equantum number n

A. VR

B. RE

C. VE^{-}

D. RE^{-}

Answer: A::C

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11. When Z is doubled in an atom, which of the following statements are consistent with Bohr's theory?

A. Energy of a state is doubled

B. Radius of an orbit is doubled

C. Velocity of electrons in an orbit is doubled

D. Radius of an orbit is halved

Answer: C::D

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12. If electron of hydrogen atom is replaced by another particle of same charge but of double mass then:

A. Bohr radius will increase

B. Ionization energy of the atom will be doubled

C. Speed of the new particle in a given state will be lesser than the electron's speed in same orbit

D. Gap between energy levels will now be doubled

Answer: B::D

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13. If the potential energy is taken zero at ground state of hydrogen atom in place of infinity then

A. Total energy of atom will get changed

B. Binding energy of hydrogen atom in ground state will remain unchanged

C. Kinetic energy of electron in ground state will get changed

D. Energy of photon generated because of de-excitation of atom from first excited state will remain unchanged

Answer: A::B::D

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14. A beam of ultraviolet light of all wavelength passes through hydrogen gas at room temperature, in the x-direction. Assume that all photons emitted due to electron transitions inside the gas emerge in the y-direction. Let A and B denote the lights emerging from the gas in the x-and y-directions respectively.

(i) Some of the incident wavelengths will be absent in A

(ii) Only those wavelengths will be present in B which are absent in A

(iii) B will contain some visible light

(iv) B will contain some infrared light

A. Some of the incident wavelengths will be absent in A

B. Only those wavelengths will be present in B which are absent in A

C. B will contain some visible light

D. B will contain some infrared light

Answer: A::C::D

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15. A free hydrogen atom in ground state is at rest. A neutron of kinetic energy K collides with the hydrogen atom. After collision hydrogen atom emits two photons in succession one of which has energy 2.55eV. Assume that the hydrogen atom and neutron has same mass.

(1) Minimum value of K is 25.5eV

(2) Minimum value of K is 12.75 eV

(3) The other photon has energy 10.2eV

(4) The upper energy level is of excitation energy 12.5 eV

A. Minimum value of K is 25.5 eV

B. Minimum value of K is 12.75 eV

C. The other photon has energy 10.2 eV

D. The upper energy level is of excitation energy 12.75 eV

Answer: A::C::D

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Practice Questions Linked Comprehension

1. Hydrogen atom in its ground state is excited by means of a monochromatic radiation of wavelength 970.6Å. Different wavelengths are possible in the spectrum. After absorbing the energy of radiation, hydrogen atom goes to the excited state. After 10^{-8} s, the hydrogen atom will come to the ground state by emitting the absorbed energy.

Energy absorbed by hydrogen atom is

A. 1.82 eV

B. 2.18 eV

C. 8.12 eV

D. 12.8 eV

Answer: D

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2. Hydrogen atom in its ground state is excited by means of a monochromatic radiation of wavelength $970.6 Å$. Different wavelengths are possible in the spectrum. After absorbing the energy of radiation, hydrogen atom goes to the excited state. After 10^{-8} s, the hydrogen atom will come to the ground state by emitting the absorbed energy.

The electron of excited hydrogen atom is in which of the following energy states?

A. 2

B. 3

C. 4

D. 5

Answer: d

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3. Hydrogen atom in its ground state is excited by means of a monochromatic radiation of wavelength 970.6Å. Different wavelengths are possible in the spectrum. After absorbing the energy of radiation, hydrogen atom goes to the excited state. After 10^{-8} s, the hydrogen atom will come to the ground state by emitting the absorbed energy.

Number of different wavelengths present in the spectrum

A. 4

B. 6

C. 8

D. 5

Answer: a

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4. A beam of alpha paricles is incident on a target of lead. A particular alpha paticles comes in 'head- on' to a particular lead nucleus and stops 6.50×10^{-14} m away from the center of the nucleus. (This point is well outside the nucleus.) Assume that the lead nucleus, which has 82 protons, remains at rest. The mass of alpha particle is $6.64 \times 10^{-27} kg$

Calculate the electrostatic potential energy at the instant when the alpha particle stops?

A. 36.3 Me V

B. 45.0 MeV

C. 3.63 Me V

D. 40.0MeV

Answer: C

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5. A beam of alpha paricles is incident on a target of lead. A particular alpha paticles comes in 'head- on' to a particular lead nucleus and stops $6.50 \times 10^{-14} m$ away from the center of the nucleus. (This point is well outside the nucleus.) Assume that the lead nucleus, which has 82 protons, remains at rest. The mass of alpha particle is $6.64 \times 10^{-27} kg$ What initial kinetic energy (in joule and in MeV)did the alpha particle have?

A. 36.3

B. 0.36

C. 3.63

D. 2.63

Answer: c

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6. A beam of alpha paricles is incident on a target of lead. A particular alpha paticles comes in 'head- on' to a particular lead nucleus and stops 6.50×10^{-14} m away from the center of the nucleus. (This point is well outside the nucleus.) Assume that the lead nucleus, which has 82 protons, remains at rest. The mass of alpha particle is $6.64 \times 10^{-27} kg$ What was the initial speed of the alpha particle?

A. $132 \times 10^{2} m / s$

B. $1.32 \times 10^{2} m / s$

C. $13.2 \times 10^{2} m / s$

D. $0.13 \times 10^{2} m / s$

Answer: B

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7. Two hydrogen-like atoms A and B are of different masses and each atom contains equal number of protons and neutrons. The difference in the energies between the first Balmer lines emitted by A and B is 5.667 eV, when the atoms A and B, moving with the same velocity, strike a heavy target and rebound back with the same velocity. In the process, atom B imparts twice the momentum to the target than that A imparts.

The series emitted is

A. Lyman

B. Balmer

C. Pfund

D. Paschen

Answer: B

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8. Two hydrogen-like atoms A and B are of different masses and each atom contains equal numbers of protons and neutrons. The difference in the energies between the first Balmer lines emitted by A and B, is $5.667 eV$. When atom atoms A and B moving with the same velocity , strike a heavy target , they rebound with the same velocity in the process, atom B imparts twice the momentum to the target than that A imparts. Identify the atom A and B.

A. ${}_{3}^{2}H$

B. ${}_{2}^{1}H$

C. ${}_{2}^{3}H$

D. ${}_{1}^{2}H$

Answer: B

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9. Two hydrogen-like atoms A and B are of different masses and each atom contains equal numbers of protons and neutrons. The difference in the energies between the first Balmer lines emitted by A and B, is $5.667eV$. When atom atoms A and B moving with the same velocity , strike a heavy target , they rebound with the same velocity in the process, atom B imparts twice the momentum to the target than that A imparts. Identify the atom A and B.

A. $_4^2H$

B. $_2^4H$

C. $_1^1H$

D. $_{3}^{2}H$

Answer: A

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Practice Questions Matrix Match

1. The ground state and first excited state energies of hydrogen atom are $-13.6eV$ and $-3.4eV$, respectively. If potential energy in ground state is taken to be zero, then

Column I	Column II
(a) Potential energy in the first excited state would be	(p) 3.4 eV
(b) Total energy is the first excited state would be	(q) 23.8 eV
(c) Kinetic energy in the first excited state would be	(r) 20.4 eV
(d) Total energy in the ground state would be	(s) 13.6 eV

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2. The question is for spectral series of hydrogen atom. Column I Column II

Column I	Column II
(a) Lyman series	(p) Infrared region
(b) Balmer series	(q) Ultraviolet region
(c) Paschen series	(r) Visible region
(d) Brackett series	(s) Invisible region

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3. In a hydrogen atom, whenever there is transition of electron between different energy levels, energy is emitted or absorbed, and hydrogen spectrum is obtained. In the given table, Column I shows the names of the different series of hydrogen atom spectrum, Column II shows the energy levels from where electron transition takes place and Column III shows the EM wave region where these different series exists.

Column I		Column II		Column III	
(I)	Brackett series	(i)	Electron jumps from any of the higher states to the ground state or first state	(J)	The series of spectral lines emitted lies in far infra-red region
(II)	Lyman series	(ii)	When an electron jumps from any of the higher states to the state with $n = 3$	(K)	The series of spectral lines emitted lies in ultra-violet region
(III)	Balmer series	(iii)	Electron jumps from any of the higher states to the state with $n = 4$	(L)	The series of spectral lines emitted lies in near infra-red region
(IV)	Paschen series	(iv)	Electron jumps from any of the higher states to the state with $n = 2$	(M)	The series of spectral lines emitted lies in visible region

Which series has the following wavelength

$$v = RZ^2\left(\frac{1}{1^2} - \frac{1}{n_2^2}\right),\ n_2 = 2, 3, 4, 5, \ldots.\ ?$$

A. $(I)(iv)(M)$

B. $(IV)(ii)(L)$

C. $(II)(i)(K)$

D. $(II)(i)(K)$

Answer: A::D

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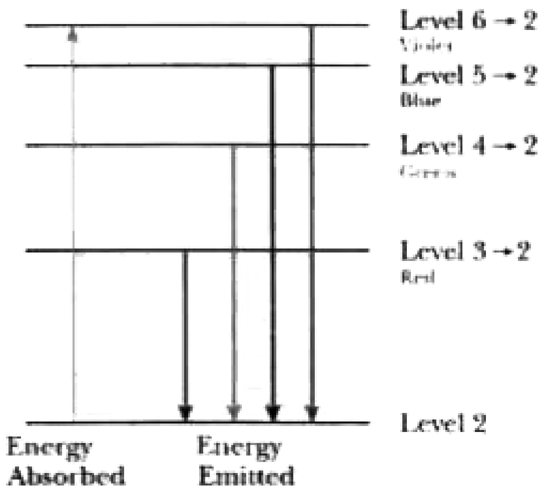
4. In a hydrogen atom, whenever there is transition of electron between different energy levels, energy is emitted or absorbed, and hydrogen spectrum is obtained. In the given table, Column I shows the names of the different series of hydrogen atom spectrum, Column II shows the energy levels from where electron transition takes place and Column III shows the EM wave region where these different series exists.

Column I	Column II	Column III
(I) Brackett series	(i) Electron jumps from any of the higher states to the ground state or first state	(J) The series of spectral lines emitted lies in far infra-red region
(II) Lyman series	(ii) When an electron jumps from any of the higher states to the state with $n = 3$	(K) The series of spectral lines emitted lies in ultra-violet region
(III) Balmer series	(iii) Electron jumps from any of the higher states to the state with $n = 4$	(L) The series of spectral lines emitted lies in near infra-red region
(IV) Paschen series	(iv) Electron jumps from any of the higher states to the state with $n = 2$	(M) The series of spectral lines emitted lies in visible region

Which series does the diagram depict?



A. $(I)(ii)(J)$

B. $(III)(iv)(M)$

C. $(II)(iii)(L)$

D. $(I)(i)(M)$

Answer: A::B

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5. In a hydrogen atom, whenever there is transition of electron between different energy levels, energy is emitted or absorbed, and hydrogen spectrum is obtained. In the given table, Column I shows the names of the different series of hydrogen atom spectrum, Column II shows the energy levels from where electron transition takes place and Column III shows the EM wave region where these different series exists.

Column I	Column II	Column III
(I) Brackett series	(i) Electron jumps from any of the higher states to the ground state or first state	(J) The series of spectral lines emitted lies in far infra-red region
(II) Lyman series	(ii) When an electron jumps from any of the higher states to the state with $n = 3$	(K) The series of spectral lines emitted lies in ultra-violet region
(III) Balmer series	(iii) Electron jumps from any of the higher states to the state with $n = 4$	(L) The series of spectral lines emitted lies in near infra-red region
(IV) Paschen series	(iv) Electron jumps from any of the higher states to the state with $n = 2$	(M) The series of spectral lines emitted lies in visible region

Which series has the following wavelength

$$v = RZ^2\left(\frac{1}{4^2} - \frac{1}{n_2^2}\right)?$$

A. $(II)(ii)(J)$

B. $(I)(iii)(J)$

C. $(IV)(i)(L)$

D. $(II)(iii)(M)$

Answer: A::B::C

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6. Different hydrogen spectral series have different wave- lengths. In the given table, Column I shows the values of energy levels between which electronic transition takes

place, Column II shows the formula of maximum wave- length of different spectral series and Column III shows the formula of minimum wavelength of different spectral series

Column I	Column II	Column III
(I) $n_2 = 2, 3, 4, \ldots, \infty$; $n_1 = 1$	(i) $\lambda_{max} = \frac{36}{5R}$	(J) $\lambda_{min} = \frac{25}{R}$
(II) $n_2 = 3, 4, 5, \ldots, \infty$; $n_1 = 2$	(ii) $\lambda_{max} = \frac{4}{3R}$	(K) $\lambda_{min} = \frac{1}{R}$
(III) $n_2 = 6, 7, 8, \ldots, \infty$; $n_1 = 5$	(iii) $\lambda_{max} = \frac{144}{7R}$	(L) $\lambda_{min} = \frac{4}{R}$
(IV) $n_2 = 4, 5, 6, \ldots, \infty$; $n_1 = 3$	(iv) $\lambda_{max} = \frac{900}{11R}$	(M) $\lambda_{min} = \frac{9}{R}$

Determine the wavelengths, λ_{max} and λ_{min} for Balmer series.

A. $(II)(i)(L)$

B. $(III)(ii)(K)$

C. $(I)(i)(L)$

D. $(I)(iii)(J)$

Answer: A

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7. Different hydrogen spectral series have different wave- lengths. In the given table, Column I shows the values of energy levels between which electronic transition takes place, Column II shows the formula of maximum wave- length of different spectral series and Column III shows the formula of minimum wavelength of different spectral series

Column I	Column II	Column III
(I) $n_2 = 2, 3, 4, \ldots, \infty$; $n_1 = 1$	(i) $\lambda_{max} = \frac{36}{5R}$	(J) $\lambda_{min} = \frac{25}{R}$
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(III) $n_2 = 6, 7, 8, \ldots, \infty$; $n_1 = 5$	(iii) $\lambda_{max} = \frac{144}{7R}$	(L) $\lambda_{min} = \frac{4}{R}$
(IV) $n_2 = 4, 5, 6, \ldots, \infty$; $n_1 = 3$	(iv) $\lambda_{max} = \frac{900}{11R}$	(M) $\lambda_{min} = \frac{9}{R}$

Determine the wavelengths λ_{max} and λ_{min} for Pfund series.

A. $(I)(ii)(M)$

B. $(III)(iv)(J)$

C. $(II)(ii)(K)$

D. $(II)(iv)(M)$

Answer: A::B

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8. Different hydrogen spectral series have different wave- lengths. In the given table, Column I shows the values of energy levels between which electronic transition takes place, Column II shows the formula of maximum wave- length of different spectral series and Column III shows the formula of minimum wavelength of different spectral series

Column I	Column II	Column III
(I) $n_2 = 2, 3, 4, \ldots, \infty$; $n_1 = 1$	(i) $\lambda_{max} = \frac{36}{5R}$	(J) $\lambda_{min} = \frac{25}{R}$
(II) $n_2 = 3, 4, 5, \ldots, \infty$; $n_1 = 2$	(ii) $\lambda_{max} = \frac{4}{3R}$	(K) $\lambda_{min} = \frac{1}{R}$
(III) $n_2 = 6, 7, 8, \ldots, \infty$; $n_1 = 5$	(iii) $\lambda_{max} = \frac{144}{7R}$	(L) $\lambda_{min} = \frac{4}{R}$
(IV) $n_2 = 4, 5, 6, \ldots, \infty$; $n_1 = 3$	(iv) $\lambda_{max} = \frac{900}{11R}$	(M) $\lambda_{min} = \frac{9}{R}$

Determine the wavelength, λ_{max} and λ_{min} for Paschen series.

A. $(III)(i)(L)$

B. $(IV)(i)(J)$

C. $(III)(iv)(J)$

D. $(IV)(iii)(M)$

Answer: A::C::D

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Practice Questions Integer Type

1. The radius of hydrogen atom in its ground state is $5.3 \times 10^{-11} m$. After collision with an electron, it is found to have a radius of $21.2 \times 10^{-11} m$. What is the principal quantum number of the final state of the atom?

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2. An electron is placed in an orbit about a nucleus of charge +Ze. It requires 47.2 eV energy to excite an electron from second Bohr orbit to third Bohr orbit. What is the value of Z?

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3. A hydrogen-like atom (described by Bohr's model) is observed to emit six wavelengths originating from all possible transitions between a group of levels. These levels have energies between -0.85 eV and -0.544 eV (including both these values). Find the atomic number of the atom.

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4. Determine the energy of the photon (in eV) emitted when the electron in a hydrogen atom undergoes a transition from the n = 8 level to then = 6 level.

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5. An electron is in the ground state of a hydrogen atom. A photon is absorbed by the atom and the electron is excited to the n= 2 state. What is the energy in eV of the photon?

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6. Two possible states for the hydrogen atom are labeled A and B. The maximum magnetic quantum number for state A is +3. For state B, the maximum value is +1. What is the ratio of the magnitudes of the orbital angular momenta, L_A / L_B, of an electron in these two states ?

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