PHYSICS

BOOKS - MODERN PUBLISHERS PHYSICS (HINGLISH)

ATOMS

Solved Examples

1. Calculate the distance of closest approach when a proton of energy 3 MeV approaches a

gold nucleus (Z=79).

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2. Calculate the energy of an α-particle whose distance of closest approach with the gold nucleus is 29.5 fermi.

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3. An α-particle of velocity 2.3×10^7 m/s exhibits back scattering by a gold foil

(Z=79).Predict the maximum possible radius of the gold nucleus approximately Charge of mass ratio for α-particle is 4.8×10^7 C/kg.

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4. An α-particle is accelerated through a potential of 1MV and falls on a silver foil (Z=47).

Calculate : (i)Kinetic energy of the α-particle when it falls on the foil .

(ii)Kinetic energy of the α-particle when it is

6.9×10^{-14} m distant from the nucleus .

(iii)Distance of closest approach to the nucleus .

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5. In an α-particle scattering experiment , 100 particles are scattered per minute at an angle of 60° . Calculate the number of particles per minute scattered at an angle of 30°

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6. What is the impact parameter of an α-particle of initial energy 5 MeV scattered by 60° for Z=79 ?

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7. Calculate the angular momentum of an electron in the second orbit of an atom ?

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8. Calculate the radius of smallest orbit of a hydrogen atom.

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9. What is the velocity of electron in Bohr's third orbit of hydrogen atom ? Also calculate the number of revolutions the electron makes in Bohr's third orbit in one second.

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10. Calculate the speed of the electron in n=2 orbit of Li^{++} ion.

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11. The energy of an electron in the nth orbit is given by $E_n = -13.6/n^2 eV$. Calculate the energy required to excite an electron from ground state to the second excited state.

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12. Calculate the energy required to separate a hydrogen atom into a proton and an electron if the orbital radius is 5.3×10^{-11} m. Also calculate the velocity of the electron in a hydrogen atom.

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13. A $10kg$ satellite circles earth once every $2hr$ in an orbit having a radius of $8000km$. Assuming that Bohr's angular momentum postulate applies to satellites just as it does

to an electron in the hydrogen atom, find the quantum number of the orbit of the satellite.

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14. In the ground state of hydrogen atom, its Bohr radius is $5.3 \times 10^{-11} m$. The atom is excited such that the radius becomes $21.2 \times 10^{-11} m$. Find the value of principal quantum number and total energy of the atom in excited state.

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15. The ground state energy of the hydrogen atom is 13.6 eV. Calculate

(i)the kinetic energy of the electron in the 1^{st} excited state.

(ii)the potential energy of the electron in the 3^{rd} excited state.

(iii)frequency of the photon emitted if the electron jumps from the 3^{rd} excited state of 1^{st} excited state.

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16. Electron in a hydrogen atom makes a transition from higher energy states to n=2. Calculate the maximum possible wavelengths in this transition.

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17. In a hydrogen atom , an electron makes a transition from energy level of -1.51 eV to ground level . Calculate the wavelength of the spectral line emitted and identify the series of hydrogen spectrum to which this wavelength belongs.

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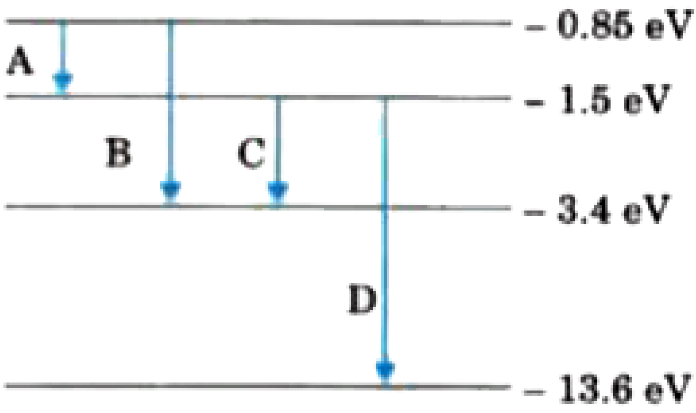
18. The energy level diagram of an element is given below. Identify , by doing necessary calculation , which transition corresponds to the emission of a spectral line of wavelength

102.7 nm



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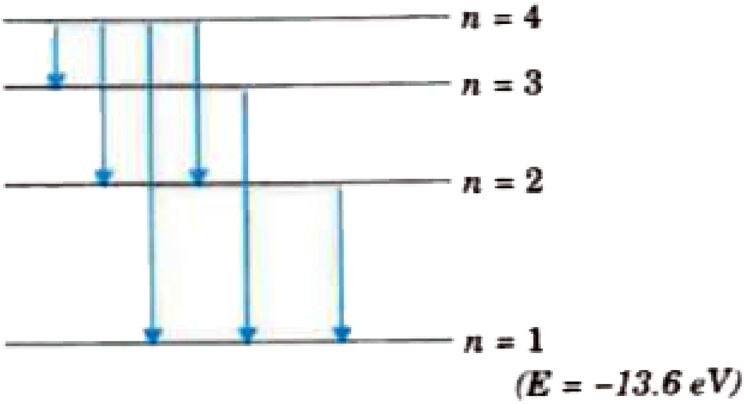
19. Energy level diagram of a hydrogen atom is shown below :



(i)If a transition takes place from n=3 to n=2 orbit, calculate the wavelength of the radiation emitted. Identify the spectral series to which it belongs.

(ii)Which transition results in emission of radiation of maximum wavelength ?

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20. If the wavelength of the first member of Balmer series in hydrogen spectrum is 6563 Å, calculate the wavelength of the first member of Lymen series in the same spectrum.

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21. Which is the shortest wavelength in the Balmer series of hydrogen atoms ?

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22. Calculate the longest wavelengths belonging to Lyman and Balmer series. Which of these wavelengths will lie in the visible region ?

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23. The wavelength of H_{α} line in the Balmer series is 6563 Å . Compute the value of Rydberg constant and hence obtain the wavelength of H_{β} line of Balmer series.

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24. A $12.9eV$ beam of electrons is used to bombard gaseous hydrogen atom at room temperature. Up to which energy level the hydrogen atoms would be excited?

Calculate the wavelength of the first member of Paschen series and first member of Balmer series.

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25. A proton traps a free electron to form the hydrogen atom of lowest energy level. If photon is emitted in this process then what will be its wavelength. Assume initial kinetic energy of the electron to be zero.

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26. Which state of triply ionised Beryllium (Be^{+++}) the same orbital radius as that of the ground state hydrogen ?

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27. Find the wavelengths in a spectrum of hydrogen atom between 600 nm to 700 nm

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28. Calculate the minimum wavelength emitted by an X-ray tube which is operated at a potential difference of 20 kV.

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29. A potential difference of 40,000 V is applied between the filament and the target metal inside X-ray tube. It is found that a current of 1 mA flows in the tube.

(i)How many electrons are hitting the target metal per second ?

(ii)Calculate the amount of energy falling on target metal per second in the form of kinetic energy of the electron .

(iii)What will be the cutoff wavelength of X-rays produced from this tube ?

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30. A potential difference of 40 kV is applied between the target metal and the filament of an X-ray tube . One electron gets accelerated through this potential difference and loses 10% of its kinetic energy in first collision. What will be the frequency of emitted photon ?

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31. There is one isolated atom of iron which emits K_{α} X-rays of energy 6.4 keV . With what kinetic energy, the iron atom will recoil If mass of iron atom is 9.3×10^{-26} kg.

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32. Heat is produced at a rate of 250 J per second in an X-ray tube when potential difference of 20 kV is applied between filament and target metal. How much current flows through the tube ? Assume only a small fraction of kinetic energy of electrons is converted into X-rays.

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33. Electrons in a television are accelerated through a potential difference of 30 kV before they strike the screen. Calculate the wavelength of the most energetic X-ray photon emitted from it.

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Practice Problems

1. Calculate the distance of closest approach for a proton with energy 3 MeV approaching a gold nucleus.

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2. In a geiger - marsden experiment. Find the distance of closest approach to the nucleus of a 7.7 me v α- particle before it comes momentarily to rest and reverses its direction.

(z for gold nucleus = 79) .

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3. In a Geiger-Marsden experiment, an α-particle of kinetic energy 4 MeV is scattered by 8° while approaching towards gold (Z =79) nucleus. Calculate impact parameter.

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4. The distance of closest approach of an alpha particle to the nucleus of gold is 2.73×10^{-14} m. Calculate the energy of the alpha particle.

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5. In Rutherford's nuclear model of the atom, the nucleus (radius about $10^{-15}m$) is analogous to the sun about which the electron moves in orbit (radius about $10^{-10}m$

) like the earth orbits around the sun. If the dimensions of the solar system had the same proportions as those of the atom, would the earth be closer to or further away form the sun than actually it is ? The radius of earth's orbit is about is $1.5 \times 10^{11} m$. The radius of the sun is taken as $7 \times 10^{8} m$.

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6. Energy of an electron in a hydrogen atom is calculated as $E_n = \dfrac{-13.6}{n^2}$ eV. Is it possible for an electron in hydrogen atom to have energy of 2.8 eV

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7. The hydrogen is excited and its Bohr radius changes from 5.3×10^{-11} m to 47.5×10^{-11} m. Calculate the principal quantum number and also find the total energy of atom.

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8. Evaluate Rydberg's constant.

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9. It is found experimentally that $13.6eV$ energy is required to separated a hydrogen atom into a proton and an electron. Compute the orbital radius and velocity of electron in a hydrogen atom.

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10. According to classical electromagnetic theory, calculate the initial frequency of the light emitted by the electron revolving around a proton in hydrogen atom.

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11. Using the Rydberg formula, calculate the wavelength of the first four spectral lines in the Lyman series of the hydrogen spectrum.

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12. Determine the smallest wavelength in Lyman series among first four spectral lines in of hydrogen atom using Bohr's formula of energy quantisation .

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13. Use Bohr's formula to calculate the energy required to excite the electron from ground state to second level of helium (He^{+}) atom. Use Z = 2.

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14. Li has 3 electrons with electronic configuration 2, 1. Calculate the energy required to remove the electron from Li^{++}

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15. A 12.5 eV electron beam is used to bombard gaseous hydrogen at room temperature. Upto which energy. Level the hydrogen atoms would be excited ? Calculate the wavelengths of the first memeber of Lyman and first member of Balmer series.

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16. The electron in hydrogen atom is initially in the third excited state. What is the maximum number of spectral lines which can be emitted, when it finally moves to the ground state?

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17. Calculate the ratio of shortest wavelength possible in Lyman and Balmer series.

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Conceptual Questions

1. In Geiger-Mersden experiment, detection of α-particles scattered at a particular angle is done by

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2. Define the distance of closest approach. An α-particle of kinetic enegy $'K'$ is bombarded on a thin gold foil. The distance of the closest approach is $'r'$. What will be the distance of closest approach for an α-particle of double the kinetic energy ?

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3. Why do the electrons revolve around the nucleus?

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4. Most of the α-particles passed through the foil undeviated . What can be concluded from this observation ?

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5. What will happen if a hydrogen atom absorbs a photon of energy greater than 13.6 eV?

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6. How does the radius of orbit change with the principal quantum number?

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7. A hydrogen atom is in second excited state. Calculate the maximum possible spectral lines emitted for hydrogen atom to reach its ground state.

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8. Calculate the kinetic energy and potential energy of electron in hydrogen atom in its ground state.

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9. According to the Bohr's atomic theory, what will be the energy of hydrogen atom For infinite quantum number number?

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10. Explain the significance of negative energy of electron in an orbit.

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11. α- particles scattering experiment helped to detect the existence of the nucleus. The main observation of this experiment is

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Tough Tricky Problems

1. Obtain an expression for the frequency of radiations emitted when a hydrogen atom de-excites from level n to level (n-1). for larger n, show that the frequency equals the classical frequency of revolution of the electron in the orbit.

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2. When a hydrogen atom emits a photon in going from n=5 to n=1, its recoil speed is almost

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3. A particle known as mu meson has a charge equal to that of no electron and mass 208 times the mass of the electron B moves in a circular orbit around a nucleus of charge $+3e$ Take the mass of the nucleus to be infinite

Assuming that the bohr's model is applicable to this system (a)drive an expression for the radius of the nth Bohr orbit (b) find the value of a for which the radius of the orbit it appropriately the same as that at the first bohr for a hydrogen atom (c) find the wavelength of the radiation emitted when the u - mean jump from the orbit to the first orbit

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4. Electron in a hydrogen-like atom $(Z = 3)$ make transition from the forth excited state to the third excited state and from the third excited state to the second excited state. The resulting radiations are incident potential for photoelectrons ejested by shorter wavelength is $3.95 eV$.

Calculate the work function of the metal and stopping potiential for the photoelectrons ejected by the longer wavelength.

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5. The radiation emitted when an electron jumps from $n = 3 \to n = 2$ orbit in a hydrogen atom falls on a metal to produce photoelectron. The electron from the metal surface with maximum kinetic energy are made to move perpendicular to a magnetic field of $(1/320)T$ in a radius of $10^{-3}m$. Find (a) the kinetic energy of the electrons, (b) Work function of the metal , and (c) wavelength of radiation.

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6. A moving hydrogen atom makes a head-on collision with a stationary hydrogen atom. Before collision, both atoms are in ground state and after collision they move together . What is the minimum atom , such that one of the atoms reaches one of the excitation state.

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7. Assume a hypothetical hydrogen atom in which the potential energy between electron and proton at separation r is given by $U = \left[k \ln r - \left(\frac{k}{2}\right)\right]$, where k is a constant. For such a hypothetical hydrogen atom, calculate the radius of nth Bohr orbit and energy levels.

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8. Assuming Bohr's atomic model find (a)largest wavelength in Balmer series, (b)the excitation energy of n=3 level of He^+ atom.

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9. A hydrogen like atom (atomic number Z) is in a higher excited state of quantum number n. The excited atom can make a transition to the first excited state by successively emitting two photons of energy 10.2 eV and 17.0 eV, respectively. Alternatively, the atom from the same excited state can make a transition to the second excited state by successively emitting two photons of energies 4.25 eV and 5.95 eV, respectively Determine the values of n and Z. (Ionization energy of H-atom = 13.6 eV)

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Ncert File

1. Choose the correct alternative form the clues given at the end of each statement:

(a) The size of the atom in Thomson's model is .... the atomic size in Rutherford's model (much greater than/no different form/much less than)

(b) In the ground state of ...., electrons are in stable equilibrium, while in.......... electrons always experience a net force (Thomson's model/Rutherford's model).

(c) A classical atom based on .... is doomed to collapse (Thomson's model/Rutherford's model).

(d) An atom has a nearly continuous mass distribution in .... but has highly non uniform mass distribution in....... (Thomson's model/Rutherford's model).

(e) The positively charge part of the atom possesses most of the mass of the atom in .... (Rutherford's ,model /both the models).

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6. Suppose you are given a chance to repeat the alpha-particle scattering experiment using a thin sheet of solid hydrogen in place of the gold foil. (Hydrogen is a solid at temperatures below 14 K.) What results do you expect?

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7. What is the shortest wavelength present in the Paschen series of spectral lines?

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8. A difference of 2.3 eV separates two energy levels in an atom. What is the frequency of radiation emitted when the atom transits form the upper level to the lower level.

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9. The ground state energy of hydrogen atom is $-13.6 eV$. What is the potential energy of the electron in this state

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10. A hydrogen atom initially in the ground level absorbs a photon , which excites it to then $n = 4$ level. Determine the wavelength and frequency of photon.

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11. (a) Using the Bohr's model, calculate the speed of the electron in a hydrogen atom in the n=1,2 and 3 levels. (b) Calculate the orbital period in each of these levels.

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12. The radius of innermost electron orbit of a hydrogen atom is $5.3 \times 10^{-11} m$. What are the radii of n=2 and n=3 orbits.?

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13. A $12.5eV$ electron beam is used to bombard gaseous hydrogen at room temperature. What serious of wavelength will be emitted?

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14. In accordance with the Bohr's model, find the quantum number that characterizes the earth's revolution around the sun in an orbit of radius $1.5 \times 10^{11} m$ with orbital speed $3 \times 10^4 m / s$. (Mass of earth=$6.0 \times 10^{24} kg$)

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15. Answer the following questions, which help you understand the difference between Thomson's model and Rutherford's model better.

(a) Is the average angle of deflection of -particles by a thin gold foil predicted by Thomson's model much less, about the same, or much greater than that predicted by Rutherford's model?

(b) Is the probability of backward scattering (i.e., scattering of α-particles at angles greater than 90°) predicted by Thomson's model much less, about the same, or much greater than that predicted by Rutherford's model?

(c) Keeping other factors fixed, it is found experimentally that for small thickness t, the number of α-particles scattered at moderate angles is proportional to t. What clue does this linear dependence on t provide?

(d) In which model is it completely wrong to ignore multiple scattering for the calculation of average angle of scattering of α -particles by a thin foil?

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16. The gravitational attraction between electron and proton in a hydrogen atom is weaker than the coulomb attraction by a factor of about 10^{-40}. An alternative way of looking at this fact is to estimate the radius of the first Bohr orbit of a hydrogen atom if the electron and proton were bound by gravitational attraction. You will find the answer interesting.

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17. Obtain an expression for the frequency of radiations emitted when a hydrogen atom de-excites from level n to level (n-1). for larger n, show that the frequency equals the classical frequency of revolution of the electron in the orbit.

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18. Classically, an electron can be in any orbit around the nucleus of an atom. Then what determines the typical atomic size? Why is an atom not, say, thousand times bigger than its typical size? The question had greatly puzzled Bohr before he arrived at his famous model of the atom that you have learnt in the text. To simulate what he might well have done before his discovery, let us play as follows with the basic constants of nature and see if we can get a quantity with the dimensions of length that is roughly equal to the known size of an atom $(\sim 10^{-10} m)$.

(a) Construct a quantity with the dimensions of length from the fundamental constants e, m_e, and c. Determine its numerical value.

(b) You will find that the length obtained in (a) is many orders of magnitude smaller than the atomic dimensions. Further, it involves c. But energies of atoms are mostly in non-relativistic domain where c is not expected to play any role. This is what may have suggested Bohr to discard c and look for 'something else' to get the right atomic size. Now, the Planck's constant h had already made its appearance elsewhere. Bohr's great insight lay in recognising that h, m_e, and e will yield the right atomic size. Construct a quantity with the dimension of length from h, m_e, and e and confirm that its numerical value has indeed the correct order of magnitude.

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19. The total energy of an electron in the first excited state of hydrogen atom is -3.4 eV.

(a) What is kinetic energy of electron in this state?

(ii) What is potential energy of electron in this state?

(c) Which of the answers above would change if the choice of zero of potential energy is changed?

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20. If Bohr's quantisation postulate (angular momentum = $nh / 2\pi$) is a basic law of nature, it should be equally valid for the case of planetary motion also. Why then do we never speak of quantisation of orbits of planets around the sun?

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21. Obtain the first Bohr radius and the ground state energy of a muonic hydrogen atom (i.e., an atom in which a negatively charged muon

(μ) of mass about $207m_e$ revolves around a proton).

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Very Short

1. The mass of a H-atom is less than the sum of the masses of a proton and electron. Why is this?

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2. Imagine removing one electron from He^4 and He^3. Their energy levels, as worked out on the basis of Bohr model will be very close. Explain why ?

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3. when an electron falls from a higher energy to a lower energy level the difference in the energies appears in the form of

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4. Would the Bohr formula for the H-atom remain unchanged if proton had a charge $(+4/3)e$ and electron a charge $(-3/4)e$, where $e = 1.6 \times 10^{-19}C$. Given reasons for you answer.

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5. Consider two different hydrogen atoms. The electron in each atom is in an excited state. Is it possible for the electrons to have different energies but the same orbital angular momentum according to the Bohr model ?

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6. Positronium is just like a H-atom with the proton replaced by the positively charged anti-particle of the electron (called the positron which is as massive as the electron). What would be the ground state energy of positronium ?

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7. Assume that their is no repulsive force be - tween the electrons in an atom but the force between positive and negative charges is given by Coulomb's law as usual . Under such circumtences, calculate the ground state energy of a He-atom.

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8. Using Bohr model, calculate the electric current created by the electron when the H-

atom is in the ground state.

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9. Show that the first few frequencies of light that are emitted when electrons falls to the nth level form levels higher than n, are approximate harmonics (i.e., in the ratio 1 : 2: 3...) when $n > \; > 1$.

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10. What is the minimum energy that must be given to a H atom in ground state so that it can emit an $H\gamma$ line in Balmer series. If the angular momentum of the system is conserved, what would be the angular momentum of such $H\gamma$ photon ?

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Hots

1. How many different wavelength may be observed in the spectrum from a hydrogen sample if the atoms excited to states with principal quantum number n?

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2. 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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3. Derive an expression for the magnetic field at the site of the nucleus in a hydrogen atom due to the circular motion of the electron Assume that the atom is in its ground state and the answer in terms of fundamental constants

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4. A proton and electron, both at rest initially, combine to form a hydrogen atom in ground state. A single photon is emitted in this process. What is the wavelength?

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5. In a discharge tube, which contains argon at low pressure, V potential difference is applied between two of its electrodes. Ionisation energy of argon atom is 15.6 eV. Separation between electrodes is 4.0×10^{-2} m and average distance that electron travels between two successive collisions with argon atoms is 8×10^{-5} m. Estimate the minimum value of V such that collision of electron may cause ionisation of argon atoms.

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Revision Exercise Very Short

1. THOMSON MODEL OF ATOM

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2. Write the two postulates of Thomson's model o fan atom .What were the drawbacks in this model?

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3. Which part of an atom was discovered by Rutherford's alpha particle scattering experiement ?

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4. Why did Rutherford select a gold foil in his α-ray scattering experiment ?

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5. What are the limitations of Rutherford's model of the atom ?

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6. What happens to the kinetic energy of the particle at the distance of closest approach?

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7. In the wave picture of light, intensity of light is determined by the squar of the amplitude of the wave. What determines the intensity of light in. the photon picture of light.

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8. Impact Parameter

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9. Define the distance of closest approach. An α-particle of kinetic enegy $'K'$ is bombarded on a thin gold foil. The distance of the closest approach is $'r'$. What will be the distance of closest approach for an α-particle of double the kinetic energy ?

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10. Write the expression for distance of closest approach for a α-particle.

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11. In Rutherford scattering experiment, if a proton is taken instead of an alpha particle, then for same distance of closest approach, how much K.E. in comparison to K.E. of α particle will be required?

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12. The angular momentum of the α- particles which are scattered through large angle by the heavier nuclei, is conserved because of the

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13. Why is electron supposed to be revolving around the nucleus?

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14. The total energy of eletcron in the ground state of hydrogen atom is $-13.6eV$. The kinetic enegry of an electron in the first excited state is

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15. In which region of electromagnetic spectrum, Lyman and Balmer series of Hydrogen spectrum falls?

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16. What is the maximum number of spectral lines emitted by a hydrogen atom when it is in the third excited state?

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17. When is H_{α} line of the emission spectrum of hydgrogen atom obtained?

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18. What are stationary waves?

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19. State Bohr's quantisation condition?

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20. With increasing member, the energy difference between adjacent levels in atoms.

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21. The energy of an electron in the nth Bohr orbit of hydrogen atom is

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22. The short wavelength limits of Lyman, Paschen and Balmer series in the hydrogen spectrum are denoted by λ_L, λ_P and λ_B respectively. Arrange these wavelength in increasing order.

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23. The velocity of electron in first orbit of H-atom as compared to the velocity of light is

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24. What is the value of Rydberg constant?

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25. Write an expression for Bohr's radius in hydrogen atom.

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26. Write an empirical relation for the Balmer series of hydrogen atom.

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27. What are the values of first and second excitation potential of hydrogen atom?

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28. Name the spectral series of hydrogen atom, which be in infrared region.

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29. The radius of innermost electron orbit of a hydrogen atom is $5.3 \times 10^{-11} m$. What is the radius of orbit in second excited state?

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30. Write the Bohr's frequency condition.

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31. EXCITATION ENERGY AND EXCITATION POTENTIAL

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32. Write the expression for total energy of an electron in n^{th} orbit.

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33. The frequency of H_{β} line of lyman seris of hydrogen is

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34. For an electron in the second orbit of hydrogen, the angular momentum as per the Bohr's model is

A. 2h

B. h

C. $\frac{h}{\pi}$

D. $\frac{2h}{\pi}$

Answer: C

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35. According to de Broglie's explanation of Bohr's second postulate of quantisation, the standing particle wave on a circular orbit for n = 4 is given by

A. $2\pi r_n = \lambda$

B. $\dfrac{2\pi}{\lambda} = 2r_n$

C. $2\pi r_n = 4\lambda$

D. $\dfrac{\lambda}{2\lambda} = 4r_n$

Answer: C

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36. Which of the following series of H-atom lies in visible range?

A. Paschen

B. Balmer

C. Lymen

D. Pfund

Answer: B

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37. The energy equivalent of one atomic mass unit is

A. 1.6×10^{-19} J

B. 6.02×10^{23} J

C. 931 MeV

D. 9.31 MeV

Answer: C

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38. The energy of an electron in the nth Bohr orbit of hydrogen atom is

A. $\frac{13.6eV}{n}$

B. $\frac{-13.6eV}{n}$

C. $\frac{13.6eV}{n^2}$

D. $\frac{-13.6eV}{n^2}$

Answer: D

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39. The nuclear model of atom was given by

A. Thomson

B. Rutherford

C. de Broglie

D. Bohr

Answer: B

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40. Which model of atom suggests that atom is a spherical cloud of positive charges with electrons embedded in it?

A. Rutherford model

B. Bohr model

C. Thomson model

D. de Broglie

Answer: C

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Revision Exercise Fill In The Blanks

1. What is the energy possessed by an electron for $n = \infty$?

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2. The series of hydrogen spectrum lying in infrared region is Paschen, Brackett and _____ series.

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3. Size of nucleus is of the order of

Watch Video Solution

4. Total energy of electron in outer orbits is........that in............. .

Watch Video Solution

5. The radius of the stationary orbit is _____proportional to the atomic number.

Watch Video Solution

6. Which of the following series in the spectrum of the hydrogen atom lies in the visible region of the electromagnetic spectrum

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7. The energy of hydrogen atom in the first excited state is ____

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8. THOMSON MODEL OF ATOM

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Revision Exercise Short Answer

1. Explain distance of closest approach and impact parameter with illustrations.

Watch Video Solution

2. Rutherford's α-particle scattering experiment led to the conclusion that :

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3. Show that the total energy of an electron in an atom is negative and it is

$$E = -\frac{e^2}{8\pi\varepsilon_0}.$$

What is the significance of the negative energy.

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4. Hydrogen atom in third excited state de-excites to the first excited state. Obtain the expressions for the frequency of radiation emitted in this process.

Also determine the ratio of the wavelengths of the emitted radiations when the atom de-excites from the third excited state to the second excited state and from the third excited state to the first excited state.

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5. In Balmer series of hydrogen atom write -

(i) the formula for calculating wavelength

(ii) range of largest and smallest wavelength

(iii) the region of the spectrum where this series lies .

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6. The short weve length limit for the Lyman series of the hydrogen spectrum is 913.4Å Calculate the short wevelength limit for Balmer series of the hydrogen spectrum.

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7. Find out the wavelength of the electron orbiting in the ground state of hydrogen atoms.

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8. Show the H_{α} and H_{β} transitions of hydrogen atom in an energy level diagram and find their wavelengths.

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9. State the three postulates of Bohr's theory of hydrogen atom.

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10. A $12.5eV$ electron beam is used to excite a gaseous hydrogen atom at room temperature. Determine the wavelengths and the corresponding series of the lines emitted.

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11. State Bohr's quantization condition of angular momentum. Calculate the shortest wavelegth of the Bracket series and state to which part of the electromagnetic spectrum does it belog.

Watch Video Solution

12. Calculate the orbital period of the electron in the first excited state of hydrogen atom.

Watch Video Solution

13. According to second postulate of bohr model, the agnular momentum (L_n) of n^{th} possible orbit of hydrogen atom is given by

Watch Video Solution

14. Give the expression for velocity of an electron in the n^{th} orbit. Explain the meanings of the symbols.

Watch Video Solution

15. (a) Using de Broglie's hypothesis, explain with the help of a suitable diagram, Bolirs seconti pusitiaie of quantization of energy levels in a hydrogen atom.

(b) The ground state energy of hydrogen atom is -13.6 eV. What are the kinetic and poientialenegies of the electron in this state?

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16. (a) State Bohr's postulate to define stable orbits in hydrogen atom. How does de Broglie's hypothesis explain the stability of these orbits ?

(b) A hydrogen atom initially in the ground state absorbs a photon which excites it to then $n = 4$ level . Estimate the frequeny of the photon.

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17. The grond state energy of hydrogen atom is $13.6eV$. If an electron makes a transition from an energy level - 1.51 eV to - 3.4 e V , calculate the wevelength of the spectrel line emitted and name the series of hydrogen spectrum to which it belongs.

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18. The radii of Bohr's orbit are directly proportional to

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19. Using Bohr's postulate, derive the expression for the orbital period of the electron moving in the nth orbit of hydrogen atom.

Watch Video Solution

20. Calculate the shortest and longest wavelength in Lyman series of hydrogen spectrum.

Watch Video Solution

21. The first member of the Balmer series of hydrogen atom has wavelength of 6563 A. Calculate the wavelength and frequency of the second member of the same series.

Watch Video Solution

22. Calculate the wavelength of the first line in the Balmer series of hydrogen spectrum.

Watch Video Solution

23. An electron in a hydrogen atom jumps from n = 5 energy level to n = 1 energy level. What are the maximum number of photons that can be emitted ?

Watch Video Solution

Revision Exercise Long Answer

1. Derive Bohr's quantisation condition for angular momentum of orbiting electron in hydrogen atom using De Broglie's hypothesis.

Watch Video Solution

2. How is the size of nucleus experimentally determined ? Write the relation between the radius and mass number of the nucleus. Show that the density of nucleus is independent of its mass number.

Watch Video Solution

3. Using the Rydberg formula, calculate the wavelength of the first four spectral lines in the Balmer series of the hydrogen spectrum.

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4. Using Bohr's postulates, derive the expression for the frequency of radiation emitted when electron in hydrogen atom undrgoes transition from higher energy state (quantum number n_i) to the lower state (n_f).

When electron in hydrogen atom jumps from energy state $n_i = 4$ to $n_f = 3, 2, 1$, identify the spectral series to which the emission lines belong.

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5. What are the limitations of Bohr's theory of hydrogen atom?

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Revision Exercise Numerical Problems

1. Find the distance of closest approach when a 6 MeV proton approaches a gold nucleus.

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2. In an α-particle scattering experiment, the number of particles scattered at an angle of 90° is 100 per minute. Calculate the number of particles scattered at an angle of 60°

Watch Video Solution

3. Calculate the impact parameter of a 6 MeV particle scattered by 60° when it approaches a gold nucleus.

Watch Video Solution

4. Calculate the energy of an a-particle if in a collision of this particle with gold nucleus, the distance of closest approach is 4.95×10^{-12} m.

Watch Video Solution

5. (a) Name different series of lines observed in hydrogen spectrum.

(b) Draw energy level diagram of hydrogen atom.

Watch Video Solution

6. Find the value of angular momentum of an electron in the 4^{th} orbit of an atom.

Watch Video Solution

7. Calculate the period of revolution of an electron revolving in the first orbit of hydrogen atom. Given radius of first orbit $= 0.53 \text{Å}$ and $c = 3 \times 10^8 \text{ ms}^{-1}$

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8. Obtain the expression for the ratio of the de Broglie wavelengths associated with the

electron orbiting in the second and third excited states of hydrogen atom.

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9. What is the shortest wavelength present in the Paschen series of spectral lines?

Watch Video Solution

10. If the wavelength of H_{α} line of Balmer seriesin hydrogen spectrum is 6.5×10^{-7}m then find the value of Rydberg constant.

Watch Video Solution

11. Given that the Bohr radius of hydrogen atom is 5.3×10^{-11} m . Determine its radius in the first excited state and calculate the total energy in this state.

Watch Video Solution

12. The electron in a hydrogen atom initially in state of quantum number n_1 makes a transition to a state whose excitation energy with respect to the ground state is 10.2 eV. If the wavelength associated with the photon emitted in this transition is 487.5 nm, find the (i) energy in eV, and (ii) value of the quantum number, n_1 of the electron in its initial state.

Watch Video Solution

13. In the ground state of hydrogen atom, its Bohr radius is $5.3 \times 10^{-11} m$. The atom is excited such that the radius becomes $21.2 \times 10^{-11} m$. Find the value of principal quantum number and total energy of the atom in excited state.

Watch Video Solution

14. (a) The radius of the innermost electron orbit of a hydrogen atom is 5.3×10^{-11} m.

Calculate its radius in n =2 orbit.

(b) The total energy of an electron in the second excited state of the hydrogen atom is -1.51 eV. Find out its (i) kinetic energy and (ii) potential energy in this state.

Watch Video Solution

15. (a) Calculate the kinetic energy and potential energy of the electron in the first orbit of hydrogen atom.

(b)Calculate the longest and shortest

wavelength in the Balmer series of hydrogen atom.

Watch Video Solution

16. Calculate the energy required to excite an electron from ground state to 3^{rd} excited state if the energy of electron in n^{th} orbit is $-13.6/n^2$

Watch Video Solution

17. A hydrogen atom in its excited state emits radiations of wavelengths 1218 Å and 974.3 Å when it finally comes to the ground state. Identify the energy levels from where transitions occur. Given Rydberg constant $R = 1.1 \times 10^7 m^{-1}$. Also specify the spectral series to which these lines belong.

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18. Find the ratio between the wavelength of the most energetic' spectral lines in the Balmer and Paschen series of the hydrogen spectrum.

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19. The period of revolution of electron in the third orbit in a H-atom is $4.132 \times 10^{-15} s$. Hence the period in the fourth orbit is

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20. Find out the ratio of energies of photons produced when an electron (i) makes transition from the second permitted level to the first level, (ii) highest permitted level to the 3^{rd} permitted level.

Watch Video Solution

21. Draw the energy-level diagram of hydrogen atom. Show the Lyman series and Pfund series in the diagram.

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22. A 12.5 eV electron beam is used to bombard gaseous hydrogen at room temperature. Upto which energy. Level the hydrogen atoms would be excited ? Calculate the wavelengths of the first memeber of Lyman and first member of Balmer series.

Watch Video Solution

23. Given the ground state energy E_0 = -13.6 eV and Bohr radius a_0 = 0.53 Å. Find out how the de Broglie wavelength associated with the electron orbiting in the ground state would change when it jumps into the first excited state.

Watch Video Solution

Competition File Objective A Mcqs

1. In a hydrogen sample atoms are excited to the state with principal quantum number n. The number of different possible wavelengths emitted is

A. $n\frac{n-1}{2}$

B. $n\frac{n+1}{2}$

C. $\frac{n^2}{2}$

D. $\frac{n^2}{2}+1$

Answer: A

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Watch Video Solution

2. A proton traps a free electron to form the hydrogen atom of lowest energy level. The wavelength of photon emitted in this process will be (assume initial kinetic energy of the electron to be zero)

A. 91.4 nm

B. 71.4 nm

C. 103.6 nm

D. 141.2 nm

Answer: A

Watch Video Solution

3. A hydrogen-like atom in its first excited state has excitation energy of 91.8 eV. The energy required to remove the electron from its ion is:

A. 91.8 eV

B. 122.4 eV

C. 183.6 eV

D. 61.2 eV

Answer: B

Watch Video Solution

4. Taking the Bohr radius $a_0 = 53$ pm, the radius of Li^{++} ion in its gnround state, on the basis of Bohr's model, will be about.

A. 15.2 pm

B. 11.3 pm

C. 53 pm

D. 17.6 pm

Answer: D

Watch Video Solution

5. A monochromatic beam of light is absorbed by a collector of ground state hydrogen atom in such a way that six different wavelengths are observed when hydrogen relaxes back to the ground state. The wavelength of the incident beam is

A. 92

B. 97

C. 88

D. 51

Answer: B

Watch Video Solution

6. If Bohr's model is applicable to an atom $\cdot_{100} X^{256}$ then its orbital radius will be

A. 5.29×10^{-11} m

B. 1.32×10^{-11} m

C. 2.64×10^{-11} m

D. 1.76×10^{-11} m

Answer: B

Watch Video Solution

7. In a hydrogen atom of radius r_n, an electron is revolving in n^{th} orbit with velocity v_n. The magnetic field at nucleus of the atom will be

A. $\frac{\mu_0 e v_n}{2\pi r_n^2}$

B. $\frac{\mu_0 e v_n}{2\pi^2 r_n^2}$

C. $\frac{\mu_0 e v_n}{4\pi r_n^2}$

D. $\frac{\mu_0 e v_n}{4\pi^2 r_n^2}$

Answer: C

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8. In an X-ray tube, electrons are liberated by heating filament and are further accelerated to a very high speed by high potential difference. These accelerated electrons are stopped by a metal target and electron's energy is liberated in the form of X-rays. On increasing the applied potential difference

A. the intensity of emitted radiation increases

B. the intensity of emitted radiation decreases

C. the minimum wavelength of emitted radiation increases

D. the minimum wavelength of emitted radiation decreases.

Answer: D

Watch Video Solution

9. In a hydrogen atom, an electron is excited to the energy state of -1.511 eV. What will be the speed of the electron in orbit, if v is the speed in its ground state?

A. Twice the speed of electron in ground state

B. Twice the speed of electron in ground state

C. The orbital speed will remain same

D. One-third of the speed of electron in ground state.

Answer: D

Watch Video Solution

10. In the Bohr's model of hydrogen atom, the ratio of the kinetic energy to the total energy of the electron in n^{th} quantum state is:

A. 1

B. -1

C. 2

D. $1/2$

Answer: B

Watch Video Solution

11. In an X-ray tube the value of applied potential difference is 81 kV. The emitted radiations may contain wavelength of

A. $2 \times 10^{-11} m, 1.2 \times 10^{-11}$m

B. $2.1 \times 10^{-11} m, 1.0 \times 10^{-11}$ m

C. $2.0 \times 10^{-11} m, 2.5 \times 10^{-11}$m

D. $1.3 \times 10^{-11} m, 1.0 \times 10^{-11}$ m

Answer: C

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12. The ratio of wavelength of K_{α} line of an element with atomic number 61 to wavelength of K_{α} line of an element with atomic number 21 is

A. $3:1$

B. $4:1$

C. $1:9$

D. $2:1$

Answer: C

Watch Video Solution

13. An element X has atomic number 21. If a is constant the frequency of K_{α} line will be

A. $200a^2$

B. $400a^2$

C. 200a

D. 400 a

Answer: B

Watch Video Solution

14. The de Broglie wavelength associated with a neutron at room temperature is 1.5 Å. The de Broglie wavelength of same at 327° C will be

A. 0.75 Å

B. 1.06 Å

C. 0.375 Å

D. 2.1 Å

Answer: B

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15. Five particles, proton, neutron, β-particle, electron and α-particle are moving with speed v.

A. de Broglie wavelength of β-particle and α-particle is longest

B. de Broglie wavelength of β-proton and neutron is longest

C. de Broglie wavelength of β-particle and electron is longest

D. de Broglie wavelength of electron and neutron is longest

Answer: C

Watch Video Solution

16. A particle of mass 4m at rest decays into two particles of masses m and 3m having non-zero velocities. The ratio of the de Broglie wavelengths of the particles 1 and 2 is

A. $3 : 1$

B. 1

C. $1 : 3$

D. $1 : \sqrt{3}$

Answer: B

Watch Video Solution

1. The ratio of kinetic energy to the total energy of an electron in a Bohr orbit of the hydrogen atom, is

A. $2 : -1$

B. $1 : -1$

C. $1 : 1$

D. $1 : -2$

Answer: B

Watch Video Solution

2. What is the radius of 2^{nd} Bohr orbit, given the radius of the first Bohr orbit is r?

A. 8r

B. 2r

C. 4r

D. $2\sqrt{2r}$

Answer: C

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3. If the ionization energy for the hydrogen atom is 13.6 eV , the energy required to excite it from the ground state to the next higher state is nearly

A. 3.4 eV

B. 10.2 eV

C. 12.1 eV

D. 1.5 eV

Answer: B

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4. In a Rutherford scattering experiment when a projectile of change Z_1 and mass M_1 approaches s target nucleus of change Z_2 and mass M_2, te distance of closed approach is r_0. The energy of the projectile is

A. directly proportional to $z_1 z_2$

B. inversely proportional to z_1

C. directly proportional to Mass M_1

D. directly proportional to $M_1 \times M_2$

Answer: A

Watch Video Solution

5. The total energy of an electron in an atom in an orbit is $-3.4eV$. Its kinetic and potential energies are, respectively:

A. 3.4eV, 3.4 eV

B. -3.4 eV , -3.4 eV

C. -3.4 eV , -6.8 eV

D. 3.4 eV, -6.8 eV

Answer: D

Watch Video Solution

6. We wish to see inside an atom. Assuming the atom to have a diameter of 100 pm, this means that one must be able to resolve a width of say 10 pm. If an electron microscope is used, the minimum electron energy required is about

A. 1.5 eV

B. 15 keV

C. 150 keV

D. 1.5 MeV

Answer: B

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7. α-particle consists of

A. 2 protons only

B. 2 protons and 2 neutrons only

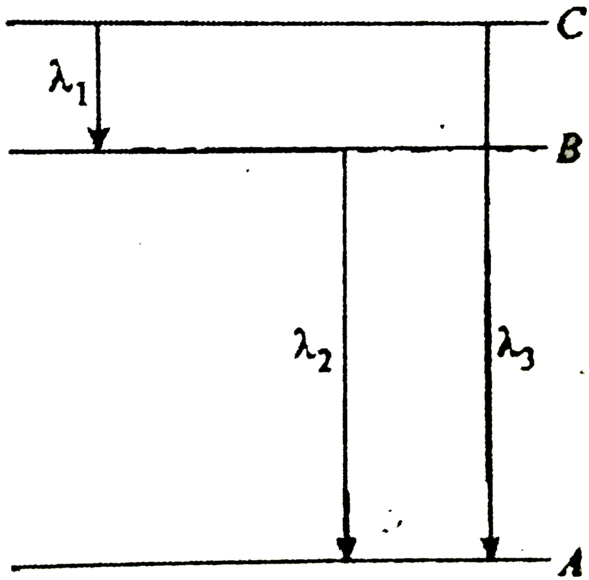
C. 2 electrons, 2 protons and 2 neutrons

D. 2 electrons and 4 protons only

Answer: B

Watch Video Solution

8. Energy levels A,B and C of a certain atom correspond to increasing values of energy i.e. $E_A < E_B < E_C$ .If $\lambda_1, \lambda_2, \lambda_3$ are the wavelengths of radiation corresponding to transition C to B,B to A and C to A respectively, which of the following statements is correct ?



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

B. $\lambda_1 + \lambda_2 + \lambda_3 = 0$

C. $\lambda_3^2 = \lambda_1^2 + \lambda_2^2$

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

Answer: D

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9. Ionization potential of hydrogen atom is 13.6 eV. Hydrogen atoms in the ground state are excited by monochromatic radiation of photon energy 12.1 eV. According to Bohr's theory, the spectral lines emitted by hydrogen will be

A. one

B. two

C. three

D. four

Answer: C

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10. Every series of hydrogen spectrum has an upper and lower limit in wavelength. The spectral series which has an upper limit of wavelegnth equal to 18752Å is

(Rydberg constant $R = 1.097 \times 10^{7}$ per metre)

A. Pfund series

B. Paschen series

C. Lyman series

D. Balmer series

Answer: B

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11. The ionization enegry of the electron in the hydrogen atom in its ground state is $13.6 ev$. The atoms are excited to higher energy levels to emit radiations of 6 wavelengths. Maximum wavelength of emitted radiation corresponds to the transition between

A. n=3 to n = 1 states

B. n =2 to n = 1 states

C. n = 4 to n = 3 states

D. n =3 to n = 2 states

Answer: C

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12. The wavelength of the first line of Lyman series for hydrogen atom is equal to that of the second line of Balmer series for a hydrogen-like ion. The atomic number Z of hydrogen-like ion is

A. 3

B. 4

C. 1

D. 2

Answer: D

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13. Electron in hydrogen atom first jumps from third excited state to second excited state and then form second excited state to first excited state. The ratio of wavelength $\lambda_1 : \lambda_2$ emitted in two cases is

A. 20/7

B. $7/5$

C. 27/20

D. 27/5

Answer: D

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14. An electrons of a stationary hydrogen atom passes form the fifth energy level to the ground level. The velocity that the atom acquired as a result of photon emission will be (m is the mass of the electron, R, Rydberg constant and h, Planck's constant)

A. $\frac{24m}{25hR}$

B. $\frac{24hR}{25m}$

C. $\frac{25hR}{24m}$

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

Answer: B

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15. Ratio of longest wavelengths corresponding to Lyman and Balmer series in hydrogen spectrum is

A. $\frac{3}{23}$

B. $\frac{7}{29}$

C. $\frac{9}{31}$

D. $\frac{5}{27}$

Answer: D

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16. Hydrogen atom in ground state is excited by a monochromatic radiation of $\lambda = 975\text{Å}$. Number of spectral lines in the resulting spectrum emitted will be

A. 3

B. 2

C. 6

D. 10

Answer: C

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17. Consider $3rd$ orbit of He^+ (Helium) using nonrelativistic approach the speed of electron in this orbit will be (given $K = 9 \times 10^9$ constant $Z = 2$ and h (Planck's constant) $= 6.6 \times 10^{-34} Js.$)

A. 1.46×10^6 m/s

B. 0.73×10^6 m/s

C. 3.0×10^8 m/s

D. 2.92×10^6 m/s

Answer: A

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18. Given the value of Rydberg constant is $10^7 m^{-1}$, the waves number of the lest line of the Balmer series in hydrogen spectrum will be:

A. $0.5 \times 10^7 m^{-1}$

B. $0.25 \times 10^7 m^{-1}$

C. $2.5 \times 10^7 m^{-1}$

D. $0.025 \times 10^5 m^{-1}$

Answer: B

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19. When an $\alpha -$ particle of mass 'm' moving with velocity 'v' bombards on a heavy nucleus of charge 'Ze' its distance of closest approach from the nucleus depends on m as :

A. $\frac{1}{\sqrt{m}}$

B. $\frac{1}{m^2}$

C. m

D. $\frac{1}{m}$

Answer: D

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20. The ratio of wavelength of the lest line of Balmer series and the last line Lyman series is:

A. 2

B. 1

C. 4

D. 0.5

Answer: C

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Competition File Objective Bb Mcqs

1. The de-Broglie wavelength (λ_B) associated with the electron orbiting in the second excited state of hydrogen atom is related to that in the ground state (λ_G) by :

A. $\lambda_B = 3\lambda_G$

B. $\lambda_B = 2\lambda_G$

C. $\lambda_B = 3\lambda_{G/3}$

D. $\lambda_B = 3\lambda_{G/2}$

Answer: A

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2. If the series limit frequency of the Lyman series is v_L, then the series limit frequency of the Pfund seriesis :

A. $\frac{v_L}{16}$

B. $\frac{v_L}{25}$

C. $25v_L$

D. $16v_L$

Answer: B

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3. An electron from various excited states of hydrogen atom emit radiation to come to the ground state. Let λ_n, λ_g be the de Broglie wavelength of the electron in the n^{th} state and the ground state respectively. Let $\underset{n}{\Lambda}$ 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)

A. $\Lambda_n^2 = A + B\lambda_n^2$

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

C. $\Lambda_n \approx A + \dfrac{B}{\lambda_n^2}$

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

Answer: C

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4. Radiation coming from transition $n = 2 \to n = 1$ of hydrogen atoms falls on helium in $n = 1$ and $n = 2$ state. What are the possible transition of helium ions as they absorb energy from the radiation?

A. $n = 2 \to n = 4$

B. $n = 2 \rightarrow n = 5$

C. $n = 2 \rightarrow n = 3$

D. $n = 1 \rightarrow n = 4$

Answer: A

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5. Taking the wavelength of first Balmer line in hydrogen spectrum ($n = 3$ to $n = 2$) as 660 nm, the wavelength of the 2^{nd} Balmer line ($n = 4$ to $n = 2$) will be:

A. 889.2 nm

B. 642.7 nm

C. 488.9 nm

D. 388.9 nm

Answer: C

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6. As an electron makes a transition from an excited state to the ground state of hydrogen-like atom / ion:

A. Its kinetic energy increases but potential energy and total energy decrease

B. kinetic energy, potential energy and total energy decrease

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

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

Answer: A

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7. If one were to apply Bohr model to a particle of mass $'m'$ and charge $'q'$ moving in a plane under the influence of a mgentic filed $'B'$, the energy of the cahrged particle in the n^{th} level will be :-

A. $n\left(\frac{hqB}{2\pi m}\right)$

B. $n\left(\frac{hqB}{4\pi m}\right)$

C. $n\left(\frac{hqB}{8\pi m}\right)$

D. $n\left(\frac{hqB}{\pi m}\right)$

Answer: B

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8. 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. 3

C. 4

D. 5

Answer: C

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9. A neutron moving with a speed v makes a head-on collision with a hydrogen in ground state kept at rest which inelastic collision will be take place is (assume that mass of photon is nearly equal to the mass of neutron)

A. 10.2 eV

B. 16.8 eV

C. 12.1 eV

D. 20.4 eV

Answer: D

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10. The energy required to remove the electron from a singly ionized Helium atom is 2.2 times the energy required to remove an electron from Helium atom. The total energy required to ionize the Helium atom ompletelyis:

A. 34 eV

B. 20 eV

C. 79eV

D. 109 eV

Answer: C

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11. According to Bohr's theory, the time averaged magnetic field at the centre (i.e. nucleus) of a hydrogen atom due to the motion of electrons in the n^{th} orbit is proportional to :

(n = principal quantum number)

A. n^{-4}

B. n^{-5}

C. n^{-3}

D. n^{-2}

Answer: A

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12. The acceleration of electron in the first orbits of hydrogen atom is

A. $\dfrac{h^2}{\pi^2 m^2 r^3}$

B. $\dfrac{h^2}{8\pi^2 m^2 r^3}$

C. $\dfrac{h^2}{4\pi^2 m^2 r^3}$

D. $\dfrac{h^2}{4\pi m^2 r^3}$

Answer: C

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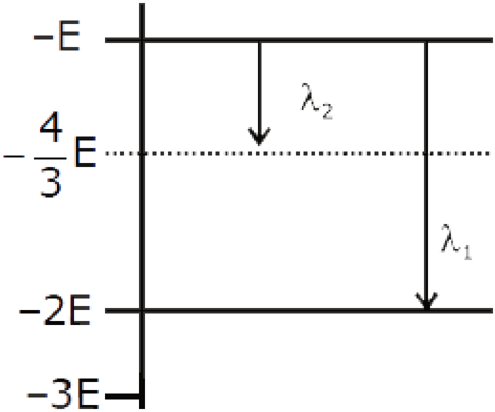
13. Some energy levels of a molecule are shown in the figure. The ratio of the wavelengths $r = \lambda_1 / \lambda_2$ is given by -



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

B. $r = \frac{2}{3}$

C. $r = \frac{3}{4}$

D. $r = \frac{1}{3}$

Answer: D

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14. An element of atomic number 9 emits K_α X-ray of wavelength λ. Find the atomic number of the element which emits K_α X-ray of wavelength 4λ.

A. 6

B. 4

C. 11

D. 44

Answer: A

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Competition File Objective C Mcqs

1. Lithium and hydrogen atom are in their second excited state. Which of the following statement/s is/are correct ?

A. Value of electronic angular momentum of hydrogen atom is greater than that of lithium.

B. Both hydrogen and lithium have same value of electronic angular momentum.

C. Both hydrogen atom and lithium have same energy

D. Excitation energy of hydrogen atom is less than that of lithium.

Answer: B::D

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2. Calculate the wavelength of radiation emitted when an electron in a hydrogen atom makes a transition from an energy level with $n = 3$ to a level with $n = 2$.

A. 654.3 nm

B. 827.5 nm

C. 487.5 nm

D. 711.5 nm

Answer: A::C

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3. In a X - ray tube , electrons accelerated through a very high potential difference strike a metal target . If the potential difference is increased , the speed of the emitted X - rays :

A. The energy of X-rays produced increases.

B. The frequency of emitted rays increases.

C. Speed of the emitted rays decreases.

D. Wavelength of emitted rays increases.

Answer: A::B

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4. In a Coolidge tube, electrons strike the target and stop inside it. Does the target get more and more negatively charged as time passes?

A. The intensity of the emitted X-rays is independent of the power supplied to the X-ray tube.

B. The cut-off wavelength of emitted X-ray increases with increase in the atomic number of metal target.

C. The cut-off wavelength of emitted X-rays is independent of atomic number of metal target.

D. The cut-off wavelength of emitted X-rays varies with applied potential difference.

Answer: C::D

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5. If the potential difference applied across a Coolidge tube is increased , then

A. The value of $\lambda_m$decreases.

B. The value of λ_α increases

C. The value of both λ_α and λ_α increases

D. The value of $(\lambda_\alpha - \lambda_m)$ increases

Answer: A::D

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6. An electron transits from n=3 to ground state in hydrogen atom. If K, P and T are kinetic energy, potential energy and total energy of the electron respectively, which of the following statements regarding the energy of electron is/are correct?

A. Only K increases

B. Only T increases

C. Both P and T decrease

D. Both P and T increase

Answer: C

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7. An electron transits for n^{th} orbit to ground in a hydrogen-like atom (Z = 11). The wavelength of emitted radiation, λ is equal to the de Broglie wavelength of electron in n^{th} orbit. Choose the correct options.

A. the value of n is 5.

B. the value of n is greater than 20.

C. the value of n is around 25.

D. the value of n lies between 5 and 20.

Answer: B::C

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8. According to Bohr's Model of hydrogen atom

A. The de Broglie wavelength of electron in n^{th} energy state is proportional to n

B. The radius of n^{th} orbit of the atom is proportional to n^2

C. The magnitude of magnetic moment of electron in n^{th} orbit is proportional to n

D. The magnetic field at the nucleus of the atom due to motion of electron in n^{th} orbit is directly proportional to n.

Answer: A::B

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9. एक स्वतन्त्र हाइड्रोजन परमाणु ,λ_a, तरंगदैर्ध्य के एक फोटॉन को अवशोषित करके n = 1 अवस्था से n = 4 अवस्था में चला जाता है । इसके तुरन्त बाद परमाणु , λ_e , तरंगदैर्ध्य का एक फोटॉन उत्सर्जित करते हुए n = m अवस्था में आ जाता है ।

मान लीजिए कि अवशोषण तथा उत्सर्जन के दौरान परगाणु के संवेग में परिवर्तन क्रमशः αp_a , तथा αp_e . है । यदि $\frac{\lambda_a}{\lambda_e} = \frac{1}{5}$ तब निम्नलिखित विकल्पों में से कौन - सा (से) सही है (हैं) ?

hc = 1242 eV nm , 1 nm = `10^(-9)' m , नियतांक और प्रकाश की गति है ।

A. λ_c = 418 nm

B. The ratio of kinetic energy of the electron in the state n=m to the state n=1 is $\frac{1}{4}$

C. m=2

D. $\Delta P_a / \Delta P_e = \frac{1}{2}$

Answer: B::C

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10. Highly excited states for hydrogen like atom (alos called Ryburg states) with nucleus Charge Ze are defined by their principal qunatum number n, where $n < \ < 1$. Which of the following statement(s) is (are) true?

A. Relative change in the radii of two consecutive orbitals does not depend on Z

B. Relative change in the radii of two consecutive orbitals varies as 1/n

C. Relative change in the energy of two consecutive orbitals varies as $1/n_3$

D. Relative change in the angular momentum of consecutive orbitals varies as 1/n

Answer: A::B::D

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Competition File Objective D Mcqs

1. Calculate the energy required to excite an electron in hydrogen atom from the ground state to the next higher state, if the ionsation energy for the hydrogen atom is $13.6eV$.

A. 2

B. 3

C. 4

D. 5

Answer: C

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2. An atom has a nucleus of charge +Ze, where Z is constant and e is electronic charge. An electron moving in a stationary orbit around nucleus requires an energy of 30.22 eV to excite from n=2 to n=3 energy state. Answer the following questions. Take ionisation energy of hydrogen as 13.6 eV.

Magnitude of angular momentum of electron in ground state is

A. $2.01 \times 10^{-34} kgm^2 s^{-1}$

B. $1.05 \times 10^{-34} kgm^2 s^{-1}$

C. $1.575 \times 10^{-34} kgm^2 s^{-1}$

D. $3.201 \times 10^{-34} kgm^2 s^{-1}$

Answer: B

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3. The ground state energy of hydrogen atom is-13.6 eV. What are the kinetic and potential energies of the electron in this state ?

A. -217.6 eV

B. -340 eV

C. -680 eV

D. -435.2 eV

Answer: D

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Competition File Assertion Reason

1. Assertion: A photosensitive surface is illuminated by a monochromatic light of wavelength λ and intensity I. The number of photoelectrons emitted per second is doubled when the intensity of light is doubled. However, the maximum speed of emitted electrons remains unchanged.

Reason: The number of electrons emitted per second is directly proportional to the intensity of the incident light. The kinetic energy of the emitted photoelectrons is independent of the intensity of the light.

A. If both assertion and reason are correct and reason is a correct explanation of the assertion.

B. If both assertion and reason are correct but is not the correct explanation of assertion.

C. If assertion is correct but reason is incorrect.

D. If assertion is incorrect but reason is correct.

Answer: A

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2. Assertion: For the scattering of α-particles at a large angles, only the nucleus of the atom is responsible.

Reason: Nucleus is very heavy in comparison to electrons.

A. If both assertion and reason are correct and reason is a correct explanation of the assertion.

B. If both assertion and reason are correct but is not the correct explanation of assertion.

C. If assertion is correct but reason is incorrect.

D. If assertion is incorrect but reason is correct.

Answer: A

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3. Assertion: A hydrogen atom cannot absorb a photon whose energy is greater than $13.6 eV$, its binding energy.

Reason: The extra energy will manifest as KE of the electron.

A. If both assertion and reason are correct and reason is a correct explanation of the assertion.

B. If both assertion and reason are correct but is not the correct explanation of assertion.

C. If assertion is correct but reason is incorrect.

D. If assertion is incorrect but reason is correct.

Answer: C

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4. Define the distance of closest approach. An α-particle of kinetic enegy $'K'$ is bombarded on a thin gold foil. The distance of the closest approach is $'r'$. What will be the distance of closest approach for an α-particle of double the kinetic energy ?

A. If both assertion and reason are correct and reason is a correct explanation of the assertion.

B. If both assertion and reason are correct but is not the correct explanation of assertion.

C. If assertion is correct but reason is incorrect.

D. If assertion is incorrect but reason is correct.

Answer: D

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5. (A) the total energy of an electron revolving in any stationary orbit is negative.

(R) energy can have positive or negative values.

A. If both assertion and reason are correct and reason is a correct explanation of the assertion.

B. If both assertion and reason are correct but is not the correct explanation of assertion.

C. If assertion is correct but reason is incorrect.

D. If assertion is incorrect but reason is correct.

Answer: C

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6. Assertion: The de Broglie wavelength of an electron in n^{th} Bohr orbit of hydrogen is inversely proportional to the square of quantum number n.

Reason: The magnitude of angular momentum of an electron in n^{th} Bohr orbit of hydrogen atom is directly proportional to n.

A. If both assertion and reason are correct and reason is a correct explanation of the assertion.

B. If both assertion and reason are correct but is not the correct explanation of assertion.

C. If assertion is correct but reason is incorrect.

D. If assertion is incorrect but reason is correct.

Answer: D

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Competition File Matching

1.

	List-I		List-II
P	The de-Broglie wavelength of electron in n^{th} Bohr orbit of hydrogen atom	1	$\propto \frac{1}{n^5}$
Q	Magnetic moment of electron in n^{th} Bohr orbit of hydrogen atom	2	$\propto n$

	List-I		List-II
R	magnetic field at the centre of hydrogen atom due to motion of electron in n^{th} orbit	3	$\propto r^{1/2}$
S	angular momentum of an electron in n^{th} orbit of hydrogen atom	4	$\propto r^2$

	P	Q	R	S
(a)	2	1	4	3
(b)	1	3	2	4
(c)	2	4	1	3
(d)	4	1	2	3

A. P-2,Q-1,R-4,S-3

B. P-1,Q-3,R-2,S-4

C. P-2,Q-4,R-1,S-3

D. P-4,Q-1,R-2,S-3

Answer: C

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Competition File Matrix Match

1.

	Column I		Column II
(A)	Alpha particle in vicinity of electric field of a nucleus in Rutherford experiment	(p)	Magnitude of total energy is equal to kinetic energy.
(B)	Motion of electron in Bohr's atomic orbit	(q)	Conservation of mechanical energy.
(C)	Motion of the Moon around the Earth	(r)	Potential energy is twice that of total energy.
(D)	Free fall in vacuum on the Earth's surface	(s)	Central force is in action.

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2.

	Column I		Column II
(A)	Orbital velocity of electron in n^{th} Bohr orbit	(p)	inversly proportional to n
(B)	Angular speed of electron in n^{th} Bohr orbit	(q)	directly proportional to Z
(C)	Current in n^{th} Bohr orbit containing an electron	(r)	directly proportional to Z^2
(D)	The de Broglie wavelength of electron in n^{th} Bohr orbit	(s)	inversally proportional to n^3
		(t)	directly proportional to n

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Competition File Integers

1. The ratio of shortest wavelength lines in Lyman , Balmer and Paschen series is 1:4:x. Calculate the value of x ?

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2. In Rutherford α-sattering experiment , the ratio of number of particles scattered at an angle of 180° to the number of particles scattered at an angle of 90° is $\alpha : 4$. What is the value of α ?

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3. Consider a hydrogen-like ionized atom with atomic number with a single electron. In the emission spectrum of this atom, the photon emitted in the 2 to 1 transition has energy 74.8 higher than the photon emitted in the 3 to 2 transition. The ionization energy of the hydrogen atom is 13.6. The value of is ________.

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4. In the Bohr's model of hydrogen atom, the radius of n^{th} orbit is proportional to n^{a}. Find the value of a if electric potential energy of the atom is given as :$U = U_0 \ln\left(\frac{r}{r_0}\right)$. Here r_0 and U_0 are constant and r is the radius of the orbit in which electron is moving arounds the nucleus .

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5. The electron is moving with a velocity $\frac{c}{3}$. The de-Broglie wavelength of electron is observed to be equal to a moving photon. The ratio of kinetic energy of electron to that energy of photon is found to be a:6. Find the value of a.

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6. Two elements X and Y have atomic number 15 and a respectively. The ratio of wavelength of K_α X-rays emitted by both is 1:4. Find the value of a

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7. A hydrogen atom in its ground state is irradiated by light of wavelength 970Å Taking $hc/e = 1.237 \times 10^{-6}$eV m and the ground state energy of hydrogen atom as $-13.6eV$

the number of lines present in the emmission spectrum is

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8. An electron is an excited state of Li^{2+} ion has angular momentum $3h/2\pi$. The de Broglie wavelength of the electron in this state is $p\pi a_0(where a_0$ is the bohr radius) The value of p is

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9. An electron ina hydrogen atom undergoes a transition from an orbit with quantum number n_i to another with quantum number n_f . V_i and V_f are respectively the initial and final potential energies of the electron. If $\frac{V_i}{V_f} = 6.25$, then the smallest possible n_f is

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Competition File Ncert Exemplar Problems

1. Taking the Bohr radius $a_0 = 53$ pm, the radius of Li^{++} ion in its gnround state, on the basis of Bohr's model, will be about.

A. 53 pm

B. 27 pm

C. 18 pm

D. 13 pm

Answer: c

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2. The binding energy of a H-atom considering an electron moving around a fixed nuclei (proton), is

$$B = -\frac{me^4}{8n^2\varepsilon_0^2h^2} \text{ (m= electron mass)}$$

If one decides to work in a frame of refrence where the electron is at rest, the proton would be movig around it. By similar arguments, the binding energy would be :

$$B = -\frac{me^4}{8n^2\varepsilon_0^2h^2} \text{ (M = proton mass)}$$

This last expression is not correct, because

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3. The simple Bohr model cannot be directly ap-plied to calculate the energy level of an atom with many electrons . This is because.

A. of the electrons not being subject to a central force

B. of the electrons colliding with each other

C. of screening effects

D. the force between the nucleus and an electron will no longer be given by Coulomb's law

Answer: a

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4. For he ground state , the electron int eh H-atom has an angular momentum $= h$, according to the simple Bohr model. Angular momentum is a vector ans hence there will be infi-nitely many orbits with the vector pointing in alll possible direction . In actuality , this is not true,

A. because Bohr model gives incorrect values of angular momentum.

B. because only one of these would have a minimum energy.

C. angular momentum must be in the direction of spin of electron.

D. because electrons go around only in horizontal orbits.

Answer: a

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5. O_2 molecules consists of two oxygen atoms. In the molecules , nuclear force between the nuclei of the two atoms

A. is not important because nuclear forces are short-ranged.

B. is as important as electrostatic force for binding the two atoms.

C. cancels the repulsive electrostatic force between the nuclei.

D. is not important because oxygen nucleus has equal number of neutrons and protons.

Answer: a

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6. Two H atoms in the ground state collide in elastically. The maximum amount by which their combined kinetic energy is reduced is

A. 10.20 eV

B. 20.40 eV

C. 13.6 eV

D. 27.2 eV

Answer: a

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7. A set of atom in an excited state decays

A. in general to any of the states with lower energy

B. into a lower state only when excited by an external electric field.

C. all together simultaneously into a lower state.

D. to emit photons only when they collide.

Answer: a

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8. An ionised H-molecules consists of an electron and wo protons. The protons are seperated by a small distance of the order of angstrom. In the ground state,

A. the electron would not move in circular orbits.

B. the energy would be $(2)^4$ times that of a H-atom.

C. the electrons, orbit would go around the protons.

D. the molecule will soon decay in a proton and a H-atom.

Answer: a,c

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9. Consider aimimg a beam of free electrons to wards free atoms . When they scatter, an electron and a protons cannot combine be produced a H-atom,

A. because of energy conservation.

B. without simultaneously releasing energy in the from of radiation.

C. because of momentum conservation.

D. because of angular momentum conservation.

Answer: a,b

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10. The bhor model for the spectra of H-atom

A. will not be applicable to hydrogen in the molecular from.

B. will not be applicable as it is for a He-atom.

C. is valid only at room temperature.

D. predicts continuous as well as discrete spectral lines.

Answer: a,b

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11. The balmer series for the H-atom can be observed

A. if we measure the frequencies of light emitted when an excited atom falls to the ground state.

B. if we measure the frequencies of light emitted due to transitions between excited states and the first excited state.

C. in any transition in a H-atom.

D. as a sequence of frequencies with the higher frequencies getting closely packed.

Answer: b,d

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12. Let $E = \frac{-1me^4}{8\varepsilon_0^2 n^2 h^2}$ be the energy of the n^{th} level of H-atom state and radiation of frequency $(E_2 - E_1)/h$ falls on it ,

A. it will not be absorbed at all

B. some of atoms will move to the first excited state.

C. all atoms will be excited to the n = 2 state.

D. no atoms will make a transition to the n

= 3 state.

Answer: b,d

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13. The simple Bohr model is not applicable to He^4 atom because

A. He^4 is an inert gas.

B. He^4 has neutrons in the nucleus.

C. He^4 has one more electron.

D. electrons are not subject to central forces.

Answer: c,d

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Chapter Practice Test

1. An α-particle with kinetic energy K is heading towards a stationary nucleus of atomic number Z. Find the distance of the closest approach.

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2. In which region of electromagnetic spectrum, Lyman and Balmer series of Hydrogen spectrum falls ?

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3. The short wavelength limits of Lyman, Paschen and Balmer series in the hydrogen spectrum are denoted by λ_L, λ_P and λ_B respectively. Arrange these wavelength in increasing order.

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4. The innermost orbits of a hydrogen atom is 5.3×10^{-11} m. What is the radius of the orbit in third excited state ?

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5. With increasing quantum numbers, the energy difference between adjacent energy level atoms

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6. In hydrogen spectrum, the shortest wavelength in Balmer series is the λ. The shortest wavelength in the Brackett series will be

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7. Draw the energy level diagram of hydrogen atom. Calculate the energy value upto fifth excited energy states of hydrogen.

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8. The electron in hydrogen atom passes form the n=4 energy level to the n=1 level. What is the maximum number of photons that can be emitted? and minimum number?

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9. for given impact parameter b, does the angle of deflection increase or decrease with increase in energy?

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10. What is the shortest wavelength present in the Paschen series of spectral lines?

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11. Using the Rydberg formula, calculate the wavelength of the first four spectral lines in the Lyman series of the hydrogen spectrum.

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12. Using Rutherford model of atom, derive an expression for the total energy of an electron in hydrogen atom.

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13. Calculate the velocity of electron in Bohr's first orbit of hydrogen atom. How many times does the electron go in Bohr's first orbit in one second ?

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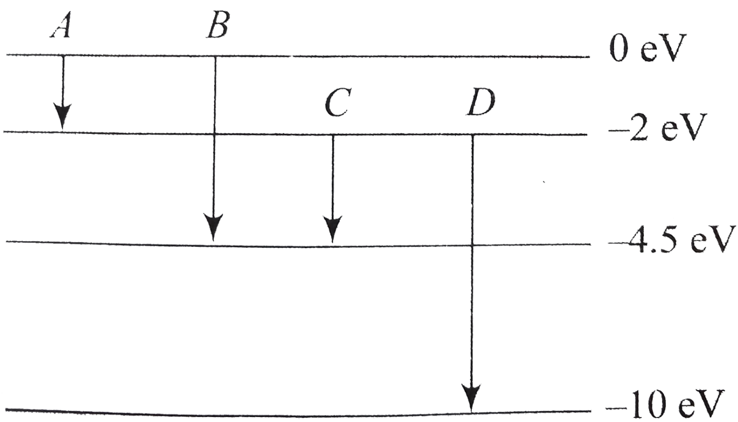
14. The energy levels of an atom are as shown in figure . Which one of those transition will result in the emission of a photon of wavelength $275nm$?



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15. The radius of the hydrogen atom in its ground state is 5.3×10^{-11} m. The principal quantum number of the final state of the atom is

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16. Describe the Rutherford's alpha particle scattering experiment. What are the conclusions of this experiment.

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