#421620

Topic: Atomic Spectra and Spectral Series

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

Solution

Ground state energy $E = -13.67eV$

$KE = -E = +13.67eV;\ PE = 2 \times KE = -27.2eV$

#421637

Topic: Bohr Model

(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.

Solution

(a) v is the orbital speed of the electron in the hydrogen atom in level n.

$$v = \frac{e^2}{n_1 4\pi\epsilon_o(h/2\pi)}$$

For $n = 1, \rightarrow \$v_1 = 2.18 \times 10^6 m/s$

For $n = 2, \rightarrow v_1 = 1.09 \times 10^6 m/s$

For $n = 3, \rightarrow v_1 = 7.27 \times 10^5 m/s$

(b) Orbital perios is given by $T = \dfrac{2\pi r}{v}; v = velocity$

Radius, $r = \dfrac{n^2 h^2 \epsilon_o}{\pi m e^2}$

So,

$T_1 = 1.527 \times 10^{-16},\ n = 1$

$T_2 = 1.22 \times 10^{-15},\ n = 2$

$T_3 = 4.12 \times 10^{-15},\ n = 3$

#421692

Topic: Bohr Model

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

A The radius of the first Bohr orbit and the estimated size of the whole universe is same.

$\boxed{\text{B}}$ The radius of the first Bohr orbit is much greater than the estimated size of the whole universe.

C The radius of the first Bohr orbit is much smaller than the estimated size of the whole universe.

D None of the above.

Solution

Radius of first bohr orbit,

$$r_1 = \frac{n^2 h^2 \epsilon_o}{\pi m e^2}$$

Coulomb force between electron and proton is

$$F_c = \frac{e^2}{4\pi\epsilon_o r^2}$$

Gravitational force $F_g = Gm_p m_e/r^2$

as $F_c = F_g$

So, $r = 1.21 \times 10^{29} m$

It is known that the universe is 156 billion light year wide or $1.5 \times 10^{27} m$. Hence, we can conclude that the radius of the first Bohr orbit is much greater than the estimated size of the whole universe.

#421788

Topic: Bohr Model

Obtain the first Bohrs 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 $207m_e$ orbits around a proton].

Solution

$m = 207m_e$, Bohr radius $r_e = 1/m_e$

For fire, Bohr orbit $r_e = 0.53 \times 10^{-10} m$

So, at equilibrium, $mr = m_e r_e$

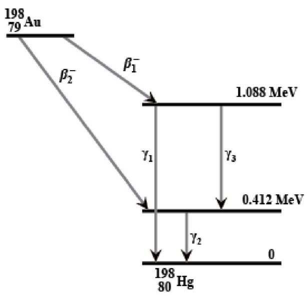
muonic hydrogen atom radius $r = 2.56 \times^{-13} m$

Also, $E_e \propto m_e; E_e = -13.6eV$

$\Rightarrow E_e/E = m_e/m \Rightarrow E = -2.81\ keV$

#422088

Topic: Atomic Spectra and Spectral Series



Obtain the maximum kinetic energy of β -particles, and the radiation frequencies of γ decays in the decay scheme shown.

You are given that

$m(^{198}Au) = 197.968233\,u$

$m(^{198}Hg) = 197.966760\,u$

Solution

It can be observed from the given γ decay diagram that γ_1 decays from the 1.088 MeV energy level to the 0 MeV energy level.

Hence, the energy corresponding to γ_1 decays is given as

$E_1 = 1.088 - 0 = 1.088 MeV$

$hv_1 = 1.088 \times 1.6 \times 10^{-19} \times 10^6 J$

Where,

h= Plank's constant and v_1 = frequency of radiation radiated by γ_1 decay.

$\therefore v_1 = \frac{E_1}{h} = \frac{1.088 \times 1.6 \times 10^{19} \times 10^6}{6.6 \times 10^{-34}} = 2.637 \times 10^{20} Hz$

It can be observed the given gamma decay diagram that γ_2 decays from the 0.412 MeV energy level to the 0 MeV energy level.

Hence, the energy corresponding to γ_2 decay is given as

$E_2 = 0.412 - 0 = 0.412 MeV$

$hv_2 = 0.412 \times 1.6 \times 10^{-19} \times 10^6 J$

Where v_2 is the frequency of the radiation radiated by γ_2 decay.

$\therefore v_2 = \frac{E_2}{h} = 9.988 \times 10^{19} Hz$

It can be observed from the given gamma decay diagram that γ_3 decays from the 1.088 MeV energy level to the 0.412 MeV energy level. Hence, the energy corresponding to

is given as

$E_3 = 1.088 - 0.412 = m0.676 MeV J$

$hv_3 = 0.676 \times 10^{-19} \times 10^6 J$

Where $v_3 =$ frequency of the radiation radiated by γ_3 decay

$\therefore v_3 = \frac{E_3}{h} = 1.639 \times 10^{20} Hz$

Now mass of Au is 197.968 u and mass of Hg = 197.9667 u

$1u = 931.5 MeV/c^2$

Energy of the highest level is given as :

$E = [m(^{198}_{78}Au) - m(^{190}_{80}Hg)] = 197.968233 - 197.96676 = 0.001473u = 0.001473 \times 931.5 = 1.3720995 MeV$

β_1 decays from the 1.3720995 MeV level to the 1.088 MeV level

$\therefore$ maximum kinetic energy of the β_1 particle $= 1.3720995 - 1.088 = 0.2840995 MeV$

β_2 decays from the 1.3720995 MeV level to the 0.412 MeV level

$\therefore$ Maximum kinetic energy of the β_2 particle = $1.3720995 - 0.412 = 0.9600995$