PHYS 111

1ST semester 1446

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Problems L12

1. **Calculate the wavelength of a photon emitted when an electron in H-atom makes a transition from n=2 to n=1.**

Solution

According to Rydberg formula, Here, n1= 1 and n2=2 and R is the Rydberg constant. Z is the atomic number of H-atom Z=1 , R= 109677 cm^{-1}

$$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)z^2$$

$$\frac{1}{\lambda} = 109677\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = 2.27\ x\ 10^{-6}\,cm$$

2. If an electron makes transition from the 7th excited state to 2nd state in a H-atom sample, find the maximum number of spectral lines observed.

Solution

The maximum number of spectral lines(N) can be calculated using the below formula:

$$N = \frac{(n_2 - n_1)(n_2 - n_1 + 1)}{2}$$

Here, n_2 = 8(for 7th excited state) and n_1= 2. Substituting in the formula, we get

$$N = \frac{(8 - 2)(8 - 2 + 1)}{2}$$

N= 21

3. The wavelength of Lyman series lies in the

a) Visible region
b) Radio Waves region
c) Ultraviolet region
d) Infrared region

Solution

c) Ultraviolet region

4. A line at 3802 cm^{-1} is obtained in the infrared region of the atomic spectrum of hydrogen. Determine the energy of this photon.

Solution

Given, λ = (1/3802) cm We know that, Energy, E= hν= hc/λ Where h is the Planck's constant and c is the speed of light, h= 6.63×10^{-34} Js , c= 3×10^{8} m/s = 3×10^{10} cm/s

E= hν= hc/λ = 7.56×10^{-20} J

5. Which electronic level allows the hydrogen atom to absorb but not emit photons?

a) 3s
b) 2p
c) 2s
d) 1s

Solution

d) 1s

6. Calculate wavelength for the 2nd line of the Balmer series of He + ion

Solution

According to the Rydberg formula

$$\frac{1}{\lambda} = R(\frac{1}{n_1^2} - \frac{1}{n_2^2})z^2$$

For the balmer series, n_1= 2 and for the second line, n_2=4

For He^+ ion, z=2 (Atomic number of Helium)

R= 109677 cm^{-1}

$$\frac{1}{\lambda} = 109677(\frac{1}{2^2} - \frac{1}{4^2})2^2$$

Thus, λ= 1.21 × 10^{-5} cm

7. Calculate the frequency of light emitted when an electron drops from the higher to the lower state if the energy difference between the two electronic states is 214.68 kJ/mol. (Planck's constant, h= 39.79× 10 -14 kJs/mol)

Solution

$\Delta E = h f$ 214.68 kJ/ mol = 39.79× 10 -14 k J s / mol × f

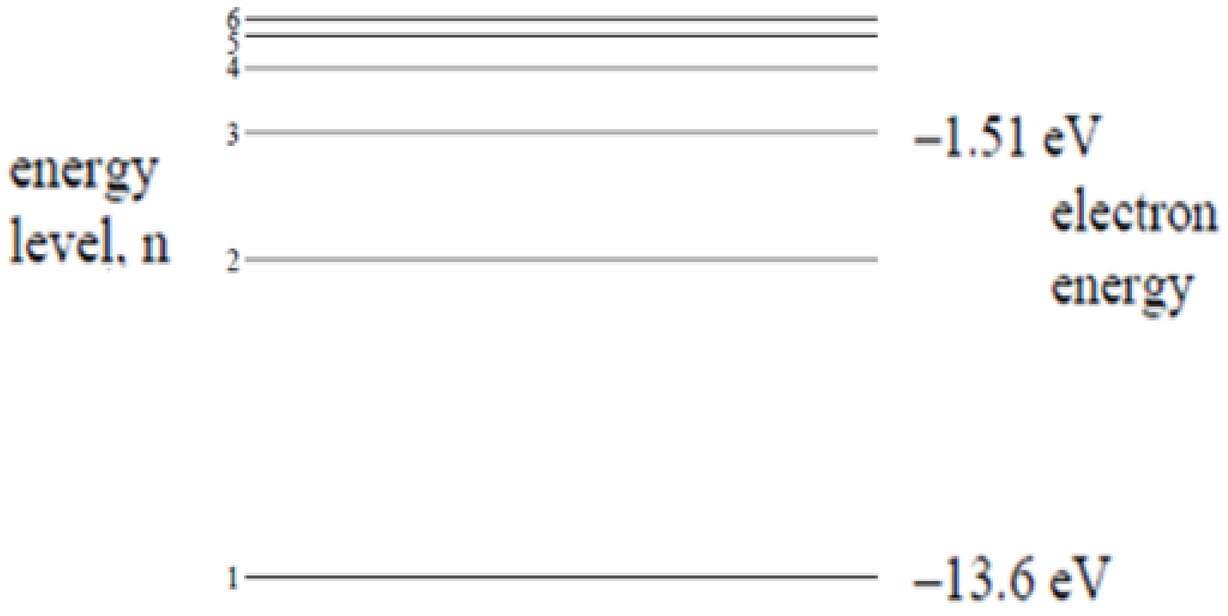
f = 5.395 × 10 14 s^{-1}

8. The diagram below represents some of the electron energy levels in the hydrogen atom.

a) To which energy level does the electron drop when it emits visible light?

b) Calculate the frequency of the photon produced when an electron drops from the second excited state (n = 3) to the ground state (n = 1). h = $6.62607015 \times 10^{-34}$ joule-hertz^{-1}

Solution



a) 2^{nd} level

b) $E = E3 - E1 = h\,f$

$f = E3\text{-}E2 / h = 2.92 \times 10^{15}$ Hz

9. Calculate the shortest wavelength of the X-ray spectrum emitted by the X-ray production device When an electron accelerated with 18750 voltage is used.

Solution

$$\lambda_m = 1.24 \times 10^{-6} / V = 1.24 \times 10^{-6} /(18750) = 6.61 \times 10^{-11}\ m$$

10. The wavelength la of the characteristic Kα spectral line of a given element is 0.07228 nm Calculate the atomic number of that element

Solution

$$\frac{1}{\lambda_\alpha} = RZ_{eff}^2 \left(\frac{1}{1^2} - \frac{1}{2^2}\right) = \frac{3}{4} RZ_{eff}^2$$

$$, Z_{eff} = Z - 1$$

$$, R = 1.09737 \times 10^7 m^{-1}$$

$1/\lambda_\alpha = 1/.07228 \times 10^{-9} = 3/4 \times 1.09737 \times 10^7 Z^2_{eff}$

$Z^2_{eff} = 168$

$Z_{eff} = 12.9 = 13$

$Z = Z_{eff} + 1 = 14$ (Si)