Key Concepts

Chapter 11

Energy levels in hydrogen atoms

Wavelength/frequency

Energy units

Takeaways

Remember that the energy of the photon must be equal to the energy lost by the electron. This is due to the conservation of energy. Alternately, when a photon is absorbed by an atom, the gain in energy of the electron is the energy of the photon.

Things to Watch Out For

Remember that "completely ionized" means that an electron has an energy equal to zero (this corresponds to an infinite quantum number n).

Energy Emission from Electrons

An electron in a hydrogen atom moves from the third energy level to the ground state. What is the wavelength of the emitted photon? ($1\text{ eV} = 1.6 \times 10^{-19}\text{ J}$; $h = 6.63 \times 10^{-34}\text{ J}\cdot\text{s}$.)

1) Determine the difference in energy between the energy levels.

For hydrogen, $E = \frac{-13.6\text{ eV}}{n^2}$

$$E_1 = \frac{-13.6}{(1)^2} = -13.6\text{ eV}$$

$$E_3 = \frac{-13.6}{(3)^2} = -1.51\text{ eV}$$

$$\Delta E = E_3 - E_1 = 12.09\text{ eV}$$

The energy values for hydrogen energy levels are given by $E = \frac{-13.6\text{ eV}}{n^2}$, where E will be in electron-volts (eV). The ground state of the atom corresponds to $n = 1$. As the principle quantum number n increases, so does the energy of the electron. As the limit n goes to infinity, note that $E = 0$. Physically, this represents an atom that is completely ionized.

***Remember:** One eV is the amount of energy required to move an electron through a potential difference of 1 volt. Remember that it is related to joules by the charge of an electron, 1.6×10^{-19}.*

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2) Find the wavelength of the photon from the energy lost by the electron.

$$E = hf = \frac{hc}{\lambda}.$$

This is a combination of the equations $E = hf$ and $\lambda f = c$: $hc = 1{,}240\text{ eV}\cdot\text{nm}$.

Therefore,

$$\lambda = \frac{1{,}240\text{ eV}\cdot\text{nm}}{12.09\text{ eV}}$$

$$\lambda = 103\text{ nm}$$

On Test Day, you can quickly relate photon energy and wavelength by remembering that harmless radio waves with low energy have very large wavelengths; thus the inverse relationship.

For any photon, the energy is related to the frequency by $E = hf$. The energy of the photon must be equal to the energy lost by the electron in the transition. Use $c = f\lambda$ to convert to wavelength. Remember that for any photon, $E = \frac{1{,}240}{\lambda}$, when E is in eV and λ is in nm. Knowing this will drastically reduce your time spent on these problems.

Similar Questions

1) What energy level is occupied by an electron of a hydrogen atom, which was initially in the ground state, when a photon of wavelength 55 nm is absorbed by the atom?
2) A photon of frequency 6×10^{14} Hz is ejected from an atom when an electron changes energy states. What was the change in energy of the electron, in joules?
3) What is the maximum wavelength that a photon must have to cause a ground-state electron in a hydrogen atom to be completely ejected from the atom?