

Frumeinda- og ljósfræði

Dæmablað 5

Skilafrestur 13. Febrúar 2020 kl. 15:00

1. Hydrogen in radio astronomy (10)

In radio astronomy, hydrogen atoms are observed in which, for example, radiative transitions from $n = 109$ to $n = 108$ occur.

- (a) What are the frequency and wavelength of the radiation emitted in this transition ?
- (b) The same transition has also been observed in excited helium atoms. What is the ratio of the wavelengths of the He and H radiation ?
- (c) Why is it difficult to observe this transition in laboratory experiment ?

2. Hydrogen atom (10)

If the proton is approximated as a uniform charge distribution in a sphere of radius R , show that the shift of an s-wave atomic energy level in the hydrogen atom, from the value it would have for a point proton, is approximately

$$\Delta E_{ns} \approx \frac{2\pi}{5} e^2 |\Psi_{ns}(0)|^2 R^2$$

using the fact that the proton radius is much smaller than the Bohr radius. Why is the shift much smaller for non-s states ? The 2s hydrogenic wave function is

$$(2a_0)^{-3/2} \pi^{-1/2} \left(1 - \frac{r}{2a_0}\right) \exp\left(-\frac{r}{2a_0}\right).$$

What is the approximate splitting (in eV) between the 2s and 2p levels induced by this effect ? [$a_0 \approx 5 \times 10^{-9}$ cm for H, $R \approx 10^{-13}$ cm.]

3. **Helium atom** (10)

Sketch the low-lying energy levels of atomic He. Indicate the atomic configuration and give the spectroscopic notation for these levels. Indicate several transitions that are allowed in emission, several transitions that are allowed in absorption, and several forbidden transitions.

4. **Sodium atom** (10)

(a) The ionization energy of sodium is 5.14 eV. What is the effective charge seen by the outer electron ?

(b) If the 3s electron of a sodium atom is moved to the 4f state, the measured binding energy is 0.85 eV. What is the effective charge seen by an electron in this state ?