Háskóli Íslands
Raunvísindadeild
Eðlisfræði

Vor 2021

Frumeinda- og ljósfræði

Dæmablað 5

Skilafrestur 18. Febrúar 2021 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. **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 ?

3. **Jónunarorka litíns – Ionization energy of lithium** (10)

(a) Notið Bohrlíkanið, til að meta fyrstu jónunarorku litín atóms. Gera má ráð fyrir að rafeindir á 1s hveli skermi nálega af kjarnhleðsluna, og þar með sé virk hleðsla +1e. Mælt gildi fyrstu jónunarorku er 5.39 eV. Ræðið mögulegar útskýringar á muninum milli mats ykkar og hins raunverulega gildis.

(b) Reiknið þriðju jónunarorku litín atóms. Er svarið nákvæmt ?

(a) Apply the Bohr model to estimate the 1st ionization energy of a lithium atom. You can assume that the two electrons in the 1s state essentially screen the nuclear charge, thus making its effective charge +1e. The observed value of the 1st ionization energy is 5.39 eV. Discuss possible physical reasons for the difference between the estimated and the observed value.

(b) Calculate the 3rd ionization energy of the lithium atom. Is this answer exact ?

(Próf Apríl 2020)

4. **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.]