Háskóli Íslands
Raunvísindadeild
Eðlisfræði

Vor 2021

Frumeinda- og ljósfræði

Dæmablað 3

Skilafrestur 4. febrúar 2021 kl. 15:00

1. **Lyman alpha** (10)

   Calculate the wavelength of the Lyman alpha transition (1s $\leftarrow$ 2p) in atomic hydrogen and in He^+. Express the results in both nm and cm^{-1}.

2. **Radíi með 90 % rafeindalíkur** (10)

   Fyrir vetnislíkt atóm í grunnástandi ákvarðið radía kúlu innan hverrar rafeindalíkur eru 90 % fyrir 1s ástand vetnisatóms. (Þetta krefst tölulegra reikninga og viðeigandi nálganna.)

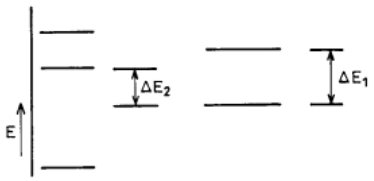
3. **Zeeman effect** (10)

   Consider the normal Zeeman effect applied to the 3d to 2p transition.

   (a) Sketch an energy-level diagram that shows the splitting of the 3d and 2p levels in an external magnetic field. Indicate all possible transitions from each m_l state of the 3d level to each m_l state of the 2p level.

   (b) Which transitions satisfy the $\Delta m_l = \pm 1$ or 0 selection rule ?

   (c) Show that there are only three different transition energies emitted.



4. **Helín atóm – Helium atom** (10)

   Myndin sýnir grunnástand sem og mengi $n = 2$ örvaðra ástanda helín atóms. Endurteiknið grafið og sýnið á myndinni

   (a) litrófstáknun allra 5 stiga

   (b) ritið stuttan texta sem útskýrir tilurð ΔE_1

   (c) ritið stuttan texta sem útskýrir tilurð ΔE_2

   (d) merkið leyfðar færslur milli þessara fimm stiga

   The figure shows the ground state and the set of $n = 2$ excited states of the helium atom. Reproduce the diagram in your answer giving

   (a) the spectroscopic notation for all 5 levels

   (b) write an explanation of the source of ΔE_1

   (c) write an explanation of the source of ΔE_2

   (d) indicate the allowed optical transitions among these five levels

   (Próf apríl 2020)

5. **Ionized helium** (10)

   An electron is in the $n = 8$ level of ionized helium.

   (a) Find the three longest wavelengths that are emitted when the electron makes a transition from the $n = 8$ level to a lower level.

   (b) Find the shortest wavelength that can be emitted.

   (c) Find the three longest wavelengths at which the electron in the $n = 8$ level will absorb a photon and move to a higher state, if we could somehow keep it in that level long enough to absorb.

(d) Find the shortest wavelength that can be absorbed.

6. **Rutherford dreifing – Rutherford scattering** (20)

Hraðall gefur róteinda geisla með 10^{12} agnir á sekúndu og skriðþunga 200 MeV/c. Geislinn ferðast um 0.01 cm þykkan ál glugga. (Al eðlismassi $\rho = 2.7$ g/cm^3, Al geislunar lengd $x_0 = 24$ g/cm^2, $Z = 13$, $A = 27$).

(a) Reikna Rutherford diffurþversnið í cm^2/sr við 30° fyrir ofangreindan geisla í áli.

(b) Hve margar róteindir lenda innan 1 cm radía á sekúndu í 2 metra fjarlægð undir 30° miðað við stefnu geislans ?

(c) Reikna heildar dreifiþversnið Rutherford fyrir horn sem er stærra en 5°.

(Hint: $\sin\theta \mathrm{d}\theta = 4 \sin\frac{\theta}{2} \cos\frac{\theta}{2} \mathrm{d}\frac{\theta}{2}$).

(d) Hve mörgum róteindum er dreift út úr geislanum undir hornum $> 5°$ á hverri sekúndu.

An accelerator provides a proton beam of 10^{12} particles per second and 200 MeV/c momentum. This beam passes through a 0.01 cm thick aluminum window. (Al density $\rho = 2.7$ g/cm^3, Al radiation length $x_0 = 24$ g/cm^2, $Z = 13$, $A = 27$).

(a) Compute the differential Rutherford scattering cross section in cm^2/sr at 30° for the above beam in Al.

(b) How many protons per second will enter a 1 cm radius circular counter at a distance of 2 meters and at an angle of 30° with the beam direction ?

(c) Compute the integrated Rutherford scattering cross section for angles greater than 5°.

(Hint: $\sin\theta \mathrm{d}\theta = 4 \sin\frac{\theta}{2} \cos\frac{\theta}{2} \mathrm{d}\frac{\theta}{2}$).

(d) How many protons per second are scattered out of the beam into angles $> 5°$.

e Coulomb scattering as 15 MeV/c.

(Próf apríl 2020)