INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

Formation Initiale aux Métiers d'Ingénieurs

Year 1
October 25th, 2024

EC Chemistry 1 – Test n°1 - Duration: 1h

No document allowed. All calculators allowed.
Answers must be concisely justified.
The results will be given with the appropriate number of significant digits.

***Data*:**
Rydberg's constant for hydrogen: $R_H = 109677\ cm^{-1}$
Planck's constant: $h = 6.626\times10^{-34}\ J.s$
Speed of Light: $c = 2.998\times10^{8}\ m.s^{-1}$
Elementary charge: $e = 1.602\times10^{-19}\ C$
Mass of the electron: $m_e = 9.10939\times10^{-31}\ Kg$
Slater's model:

Orbital of the electron	$n'<n-1$	$n'=n-1$	$n'=n$	$n'>n$
1s	-	-	0.30	0
ns,np	1.00	0.85	0.35	0
nd	1.00	1.00	1.00 for *s* and *p* 0.35 for *d*	0

Contributions of electrons occupying orbitals of quantum number n' on the screen constant of an electron that occupies an orbital of quantum number n

Exercise 1. Generalities (6 points)

1. For a hydrogen like ion, recall Ritz-Balmer's formula, giving the definition of all the terms.
2. Deduce from this Ritz-Balmer's formula the expression of the energies (in J) associated to both the long and the short-wavelength limit of a series of main quantum number n.
3. Are $_3Li^+$ and $_4Be^{3+}$ hydrogen like systems? Justify.
4. Give the definition of the ionization energy and justify its sign.

Exercise 2. Hydrogen atom (5 points)

The four first wavelengths of the emission visible spectrum of H are $\lambda = 410,\ 434,\ 486\ and\ 656\ nm$.

1. Give the transitions associated to each wavelength
2. Compute for each wavelength the value of the Rydberg's constant (to within 0.1 cm^{-1}). Comment on the obtained values.

The electron of the hydrogen atom is initially excited by an electron characterized by an energy of $4.34\text{x}10^{-18}$ J.

3 Demonstrate that this excitation corresponds to the generation of an ion (to within 0.01 J).
4 Compute the speed of the ejected electron.
5 Is the ejected electron able to ionize another hydrogen atom taken in its fundamental state?

Exercise 3. Hydrogen-like systems (6 points)

We will now work on a hydrogen-like ion such that Z=4 taken in its fundamental state. We consider that its Rydberg's constant $R_X = 109\,677\ \mathrm{cm}^{-1}$.

1. Calculate its ionization energy (to within 0.01 eV). Which spectral domain does it correspond to?
2. Compute to within 0.01 eV the energies of the 6 first levels of this ion.

An electromagnetic radiation with wavelengths ranging between 5.97 and 5.89 nm is applied to the same hydrogen like ion.

3. What phenomenon is then observed (justify your answer)?
4. In which state will then the system be? Which level is reached by the electron?
5. From the level determined in question 4 and considering a return to the fundamental state, how many rays may be observed? Justify your answer using a Grotrian's diagram.

Exercise 4. Atomistic (3 points)

1. Chromium is located in group 6 and the 4th period of the periodic table. Determine its electronic configuration and atomic number.
2. For the element of atomic number Z=30, calculate the screening constant and the effective nuclear charge Z* for an electron of its 2p subshell. Justify the calculation.

End of the exam