INSA | INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

Formation initiale aux métiers d'ingénieurs
Sections : D, E, Amerinsa, Asinsa, Scan

1st year
October 15, 2021

EC Chemistry 1 – Test 1 – Duration: 1h

No document allowed. Any non-connected calculators allowed.
Answers must be justified.
The results will be given with the appropriate number of significant figures.

Data:	
Rydberg's constant for hydrogen: R_H = 109 677 cm^{-1}	
Planck's constant: h = 6,626×10^{-34} J.s	Light speed: c = 2.998×10^{8} m.s^{-1}
Avogadro's number: N_A = 6,022×10^{23} mol^{-1}	Elementary charge: e = 1.602×10^{-19} C
Electron mass: m = 9.10939×10^{-31} kg	$E_{kinetic} = ½ mv^2$

I. Atomic spectrum of Hydrogen (~ 6 pts)

The emission spectrum of one of the series of the hydrogen atom is shown below. The lines of wavelengths λ_1, λ_2 and λ_3 are those with the highest values for this series.

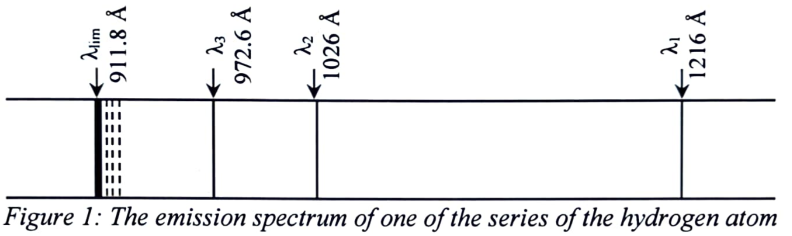

Figure 1: The emission spectrum of one of the series of the hydrogen atom

1. **In terms of energy**, for a given series in an emission spectrum, to which transitions are associated the short wavelength and the long wavelength limit, respectively?
2. Regarding the spectrum shown in Figure 1: to which domain(s) of the electromagnetic wave spectrum does this series belong to?
3. Towards which level n do the transitions involved in this series take place?
4. Calculate in eV the energy of this level n with the appropriate number of significant figures.
5. Represent on a Grotrian diagram the transitions corresponding to λ_1, λ_2, λ_3 and λ_{lim}. The numerical values of all the energy levels involved in these transitions will be given (**in eV, to the nearest 0.01 eV**) as well as the values of the associated quantum numbers.

II. About Boron (~ 8 pts)

1. The electrons of an atom are distributed in different atomic orbitals (or quantum boxes) characterized by three quantum numbers (***n, ℓ, m***$_\ell$).
   a) Name these three quantum numbers. In the general case, what values can they take?
   b) For each of the (***n, ℓ, m***$_\ell$) sets below, is there an atomic orbital that would correspond to these 3 values? If so, give the symbol of the associated **quantum subshell**.

n	*ℓ*	m_ℓ
3	2	-2
2	0	0
2	3	-3

2. Let's consider the (stable) isotope for Boron : $^{11}_{5}B$
   a) Specify the number of protons, neutrons and electrons for this isotope $^{11}_{5}B$.
   b) In which subshell(s) are located the valence electrons of this atom $^{11}_{5}B$?
   c) How many single electron(s) does this atom contain?

c

3. Give the notation associated with the hydrogen-like ion related to the Boron element.
4. The ionization energy E_i^Z of a hydrogen-like system relative to a chemical element which atomic number is Z expresses as :

$$E_i^Z = Z^2 \times E_i^H$$

where E_i^H represents the ionization energy for hydrogen, as far as **the Rydberg's constant for the hydrogen-like ion and for hydrogen are taken as equal.** This condition is supposed to apply in this exercise.

   a) Prove this relationship.
   b) Calculate the energy required to extract the electron from the hydrogen-like ion associated to the Boron element. The result will be expressed in eV, J and $kJ.mol^{-1}$ with the appropriate number of significant figures.

5. When this hydrogen-like ion is excited by a frequency band $\upsilon_{min} < \upsilon < \upsilon_{max}$, the resulting emitted spectrum is composed of six radiations. What is the maximum frequency υ_{max} of the photons used?

III. Spectroscopy for hydrogen-like systems (~ 6 pts)

As the results of two experiments, a researcher gets two absorption spectra of hydrogen-like systems that are referred by the letters A and B. The wavelength of the highest energy radiation in spectrum A is equal to 101.3 Å and that in spectrum B is equal to 25.33 Å. The value of the Rydberg constant is identical, **but not known**, for these two hydrogen-like systems.

1. Calculate the ionization energy of the two hydrogen-like systems corresponding to the spectra A and B. The result will be expressed in $kJ.mol^{-1}$ with the appropriate number of significant figures.
2. Calculate the ratio Z_B/Z_A between the atomic numbers Z_A and Z_B of the corresponding elements.
3. What condition must the ratio Z_B/Z_A satisfy for the radiation emitted by the ion of atomic number Z_B during the transition $n=4 \rightarrow n=2$ to ionize the ground state of the ion of atomic number Z_A? Is this condition fulfilled?

End of the subject