INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON PCC, Amerinsa, Asinsa, SCAN 1st *October 18th 2019*

CHEMISTRY 1 – Test 1 – Duration: 1 hour

No document allowed. All types of calculators are authorized.

Answers must be justified.

Results will be given with the appropriate number of digits.

The 3 problems are independent.

Données :	
Rydberg's constant related to hydrogen: $R_H = 109\ 677.8\ cm^{-1}$	Speed of light: $c = 2.998\times10^{8}\ m.s^{-1}$
Planck's constant: $h = 6.626\times10^{-34}$ J.s	Avogadro's number: $N_A = 6.022\times10^{23}\ mol^{-1}$
	Elementary charge: $e = 1.602\times10^{-19}$ C

Problem 1: Quantum numbers and electronic configurations (6.5 pts)

a) Give the values taken by the four quantum numbers.

b) How many electrons maximum can contain the n=3 layer?

c) On an energy scale, represent a full n=3 layer using the quantum boxes representation.

d) Give the different quantum numbers values taken by the electrons of the n=3 layer.

e) Give the values of the quantum numbers associated to the 5f sublayer.

f) Recall the 3 main rules for filling electronic layers and explain them briefly.

g) Give the electronic configurations of the following elements:
Nitrogen N (Z=7), Gallium Ga (Z=31), Silver Ag (Z=47) and Tellurium Te (Z=52).

h) Give the number of single electrons of nitrogen, gallium of silver and tellurium.

Problem 2: Study of a hydrogen-like ion (7.5 pts)

We will study a hydrogen-like ion X which has an ionization energy of 217.60 eV.
For this problem, we will consider that $R_X = R_H$.

a) Recall the definition of ionization energy for a hydrogen-like ion.

b) On the absorption spectrum of the hydrogen-like ion X, to which transition is associated the ionization energy? How is the corresponding ray called?

c) Starting from the Ritz-Balmer formula, find the literal relation that links the energy of this transition to the fundamental physical constants.

d) Give the ionization energy of hydrogen-like ion X in $kJ.mol^{-1}$.

e) Identify the hydrogen-like ion and give its formula using the form $_{Z}X^{n+}$

f) Establish the relationship between En, the energy associated to a level n, as a function of E_1 (energy of the fundamental level) and n.

g) Give the energy of levels E_1 to E_7 to within 0.01 eV.

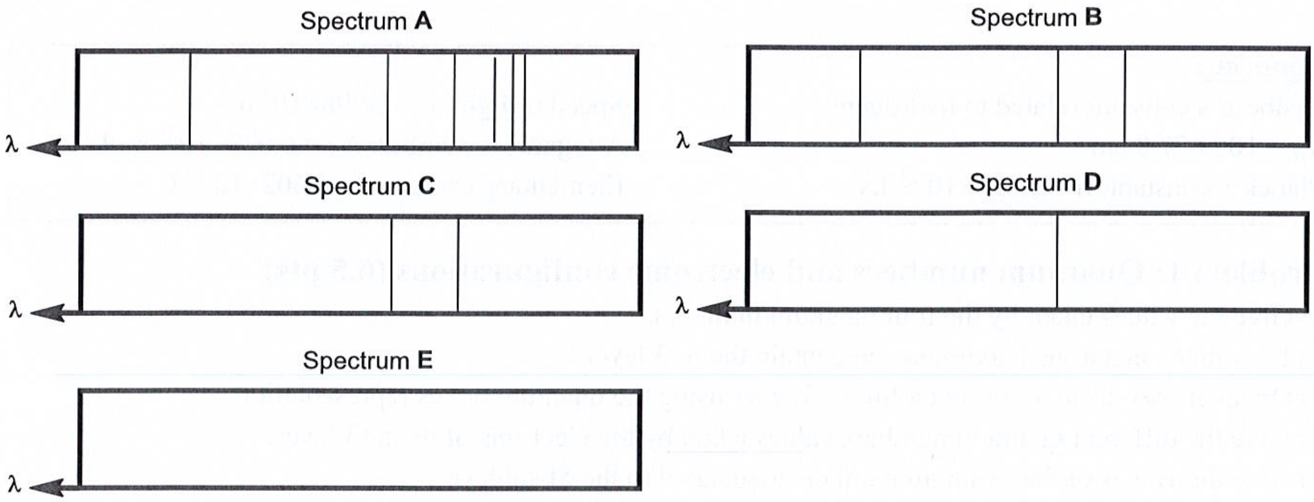
h) Represent the corresponding Grotrian's diagram.

We will now consider the emission spectrum of this hydrogen-like ion obtained after an excitation of wavelength 5.861 nm.

i) How many lines will be observed on its emission spectrum? Represent the lines on the diagram.

Problem 3: Hydrogen spectroscopy (6 pts)

Several emission spectra of atomic hydrogen were obtained using a recording setup that includes an excitation device, a hydrogen sample and a detector that records the spectrum (in this exercise you will be able to use the relationship E (eV) = 12400 / λ (Å) without demonstrating it).



a) Using the relation that allows to calculate the energy of a level $E_n = -13.60/n^2$, represent the first 5 levels of hydrogen on a Grotrian's diagram.

Three different excitation conditions were used:

Situation #1: a monochromatic radiation of wavelength 100.0 nm

Situation #2: a monochromatic radiation of wavelength 97.25 nm

Situation #3: a continuous radiation containing frequencies ranging between 2.805×10^{15} and 3.143×10^{15} Hz.

b) Knowing that the detector only records radiation in the visible range, attribute a spectra corresponding to the 3 situations. Justify your answer.

c) For situation #2, compute (if any) to within ± 1nm the values of the wavelengths of the different lines.