INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

**Formation initiale aux métiers d'ingénieurs**
**Filières : Classique, Amerinsa, Asinsa, Scan**

*1st year*
*October 12th 2018*

## Chemistry 1 - Test n°1 - Duration: 1h

*No document allowed. Any unconnected calculators are authorized*

**Answers must be justified**

**Give your answers with the appropriate number of digits**

***Data***:

Rydberg's constant for Hydrogen: $R_H$ = 109 677 $cm^{-1}$

Planck's constant: $h = 6.626\times10^{-34}$ J.s

Avogadro's number: $N_A = 6.022\times10^{23}$ $mol^{-1}$

Mass for electron: $m = 9.10939\times10^{-31}$ kg

Light celerity: $c = 2.998\times10^{8}$ $m.s^{-1}$

Elementary charge: $e = 1.602\times10^{-19}$ C

$E_{kinetic} = \frac{1}{2} mv^2$

## I. Atomic model (6 pts)

1) An electron is described by four quantum numbers $\boldsymbol{n}$, $\boldsymbol{\ell}$, $\boldsymbol{m_\ell}$ and $\boldsymbol{m_s}$. Name each quantum number and describe what they characterize and the values they can take (you can give your answers in a table).
2) Are the following statements true or false? If false, replace the statement with the correct one.

   a. If $\boldsymbol{\ell} = 1$, the electron is in a d sub-shell.

   b. If $\boldsymbol{n} = 4$, the electron is in the O shell.

   c. For a *d* electron, $\boldsymbol{m_\ell}$ can be equal to 3.

   d. The *3d* sub-shell can be occupied by a maximum of 6 electrons.

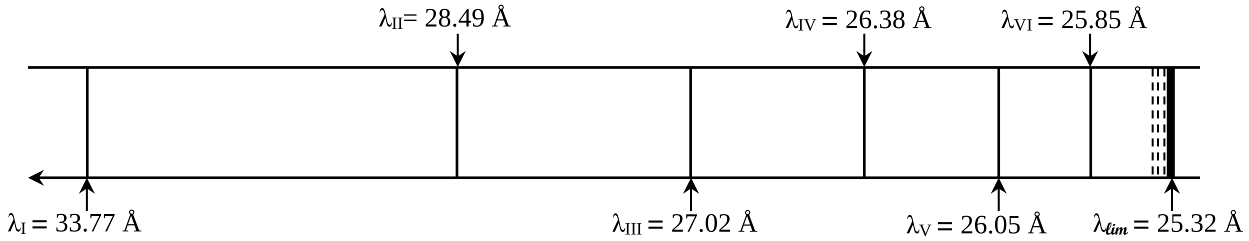
   e. The quantum number $\boldsymbol{n}$ of an electron from an f sub-shell can be equal to 3.

   f. The wavelength associated to an electron is inversely proportional to its mass.

   g. Heisenberg's indeterminacy principle has no consequence at a macroscopic scale.

## II. Spectroscopy of an hydrogen-like system (14 pts)

The following scheme represents the wavelength of the six first rays and the short-wavelength limit ($\lambda_{\ell im}$) of the **absorption spectrum** for a **hydrogen-like element $X^{n+}$** of atomic number Z. We will consider $R_X = R_H$.




1) Identify the levels of the ion involved in the **seven absorption rays** observed and compute **in eV (to within $10^{-2}$ eV)** the energy associated to each transition.

2) Give the energy of the fundamental level **$E_1$ in eV (to within $10^{-2}$ eV)** of this ion.

3) Represent on a Grotrian's diagram the energy levels of the ion and the transitions corresponding to the observed absorptions lines. Determine the Energies **in eV (to within $10^{-2}$ eV)** of the levels involved.

4) Identify the hydrogen-like ion. Represent it according to the form $_{\mathbf{Z}}\mathbf{X}^{\mathbf{n+}}$.

5) Give the ionization Energy in **kJ.mol$^{-1}$**?

6) We want to excite this hydrogen like element in order to observe only the **ray $\lambda_V$ = 26.05 Å of the absorption spectrum.** Monochromatic radiation cannot be produced, but only a continuous radiation which we can isolate a frequency range using a filter.

   a. Determine the frequency range that should be applied to observe only the **ray $\lambda_V$ = 26.05 Å**. Express the lower frequency $\nu_{min}$ and the upper frequency $\nu_{max}$ in Hz.

   b. How many lines will then be observed on its corresponding emission spectrum? Indicate them on the diagram (question 3).

   c. In this emission spectrum, there are only two radiations which energy is lower than the ionization energy of hydrogen ($remember\ that:\ \boldsymbol{E_1^H = -13.60\ eV}$).
      i. Which transitions do they correspond to?
      ii. What are their corresponding wavelengths **in nm to within 1 nm**?
      iii. To which electromagnetic domain do these radiations correspond to?

When irradiation is performed with photons, the energy of which exceeds the ionization energy of a hydrogen-like system, it is experimentally observed that the excess of energy is transferred to the ejected electron and converted into kinetic energy.

7) Which energy (**in eV to within $10^{-2}$ eV)** must be absorbed by the hydrogen-like system so that its electron is ejected with a speed of **v = $10^6$ m.s$^{-1}$**?