INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

FIMI Department
Filières : Classique, Amerinsa, Asinsa, Scan

1st year
October 12th 2018

Correction for Test I – Duration : 1h

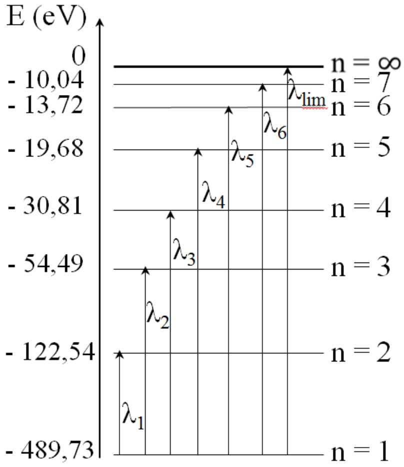
I. Atomic model (6 points)

1)	***n*** **:** main quantum number, charcaterizes the size of the orbital or numbers yhe electronic shell ; n being a positive integer (> 0) $\boldsymbol{\ell}$ **:** secondary quantum number, charcaterizes the shape of the orbital or numbers the sub-shell; $0 \leq \boldsymbol{\ell} \leq \boldsymbol{n}$-1 $\boldsymbol{m_\ell}$: magnetic quantum number or orbital, characterizes the orientatipon of the orbitals in space, or the quantum boxes, $-\boldsymbol{\ell} \leq m_\ell \leq +\boldsymbol{\ell}$ $\boldsymbol{m_s}$ **:** spin quantum number, characterizes the spin and the quantification of the kinetic moment of the electron, $\boldsymbol{m_s} = \pm 1/2$
2)	a) **FALSE :** if $\boldsymbol{\ell}$ =1, the lectron is in a p sub-shell (not d) b) **FALSE :** if **n** =4, the electron is in the N shell (not O, which n = 5) c) **FALSE :** for a d electron, as $\boldsymbol{\ell}$ =2, $\mathbf{m_\ell}$ can be equal to -2, -1, 0, 1, 2 (but not 3) d) **FALSE,** for a (3)d subshell : $\boldsymbol{\ell}$ = 2 ; $\boldsymbol{m_\ell}$ = -2, -1, 0, 1, 2 ; 5 quantum boxes, each occupied at best by 2 electrons : can be occupied by maximum 10 electrons (and not 6) e) **FALSE :** n = 3, $\boldsymbol{\ell}$ = 0, 1, 2 that correspond respectively to the s, p and d orbitals : no f exists. For an electron to be in a f-subshell ($\boldsymbol{\ell}$ = 3), n has to be at least equal to 4. f) **TRUE** g) **TRUE**

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

1)	In an **absorption spectrum**, the rays that are observed correspond to transitions from **n = 1** to **upper levels**. As wavelength and energy varies in an opposite way: λ_I owns the highest wavelength, thus corresponds to the transition with the smallest energy, thus involving levels that are the closest to each other : starting from n = 1, it corresponds to the transition from **n = 1** to **n = 2** λ_{II} owns the 2nd highest wavelength, thus corresponds to the transition with the 2nd smallest energy, thus involving the second closest level to n = 1 : it corresponds then to the transition from **n = 1** to **n = 3** etc…. $\lambda_{\ell im}$: owns the smallest wavelength, thus corresponds to the transition with the highest energy, involving the furthest level to level n = 1 : it corresponds then to the transition from **n = 1** to **n =** $\propto$ λ_I: transition n = 1 to n = 2, E_2-E_1 = $\frac{h\times c}{e\times\lambda_I}$ = 367.19 eV ; λ_{II}: transition n = 1 to n = 3, E_3-E_1 = $\frac{h\times c}{e\times\lambda_{II}}$ = 435.24 eV λ_{III}: transition n = 1 to n = 4, E_4-E_1 = $\frac{h\times c}{e\times\lambda_{III}}$ = 458.92 eV ; λ_{IV}: transition n = 1 to n = 5, E_5-E_1 = $\frac{h\times c}{e\times\lambda_{IV}}$ = 470.05 eV λ_V: transition n = 1 to n = 6, E_6-E_1 = $\frac{h\times c}{e\times\lambda_V}$ = 476.01 eV ; λ_{VI}: transition n = 1 to n = 7, E_7-E_1 = $\frac{h\times c}{e\times\lambda_{VI}}$ = 479.69 eV $\lambda_{\ell im}$: transition n = 1 to n = ∞, $E_\infty - E_1 = \frac{h\times c}{e\times\lambda_{lim}}$ = 489.73 eV *Careful with the precision that was required !!!!*
2)	From $E_\infty - E_1 = \frac{h\times c}{e\times\lambda_{lim}}$ = 489.73 eV, and as $E_\infty = 0$ and values are set as negative: E_1 = - 489.73 eV
3)	From question 1, we computed E_n - E_1. From question 2, we have E_1 Thus $E_2 = (E_2\text{-}E_1) + E_1 = \frac{h\times c}{e\times\lambda_I} + E_1$ E_2 = - 122.54 eV E_3 = - 54.49 eV E_4 = - 30.81 eV E_5 = - 19.68 eV E_6 = - 13.72 eV E_7 = - 10.04 eV

Resulting Grotrian's diagram with the energy levels and the absorption rays (each being identified!!!)



4) Using Ritz-Balmer equation and the ionization energy that corresponds to the transition from n = 1 → n∝ : $Z = \sqrt{\frac{E_i}{h \times c \times R_X}}$ = 6: thus the hydrogen-like ion is $_6X^{5+}$

5) $E_i = -E_1 \times N_A = 4.724.10^4$ kJ.mol^{-1} (careful with the number of significant digits!!!)

6) a) Ray λ_V = 26.05 Å corresponds to the transition from n = 1 to n = 6.

As we want to observe this transition, we need to provide <u>at least</u> the energy that corresponds to this transition: this defines the minimum energy (if you provide less than $E_{1\to6}$, absorption will not occur !!!).

Because we only want the given transition, we need to provide <u>strictly less</u> energy than the one required to promote the electron to n = 7: this defines the maximum energy.

Thus : $E_{1\to6} \leq E < E_{1\to7}$

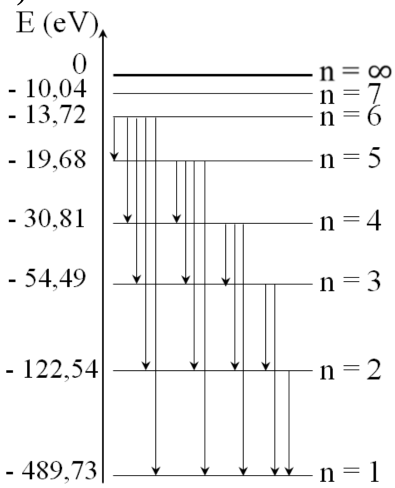
As energy and frequencies are proportional to each other, we have : $\nu_{1\to6} \leq \nu < \nu_{1\to7}$

$\nu_{1\to6} = \frac{E_6 - E_1}{h}$ = 1.151.10^{17} Hz

$\nu_{1\to7} = \frac{E_7 - E_1}{h} =$ 1.159.10^{17} Hz

(careful with the number of significant digits!!!)

b) After excitation to level n = 6, we may observe 15 rays in the corresponding emission spectrum



c) As the ionization energy for hydrogen is 13.60 eV, the two radiations that own a lower energy are:

i. Transitions from n = 6 down to n = 5 ($E_{6\to5}$ = 5.96 eV) and from n = 5 down to n = 4 ($E_{5\to4}$ = 11.13 eV)

ii. The corresponding wavelengths are then $\lambda_{6\to5}$ = 207 nm and $\lambda_{6\to5}$ = 112 nm.

iii. They belong to the UV domain

7) E_T (eV)= E_i (eV) + E_c (eV) = $E_i(eV) + \frac{1}{2}\frac{mv^2}{e} = 489.73 + 2.84 = 492.57$ eV

(careful with the precision that was required!!!)