CHEMISTRY 1 – Test n°1

Duration: 1 h

No document allowed. Only « collège » type calculators are authorized.

The marking-scheme is for information only.

I. Electronic configuration (4 pts)

1°) Name each quantum number: n, ℓ, m_ℓ and m_s, ; describe (briefly) what each number characterize and the values they range from. (You can give your answers in a table).

2°) a) One electron is located in the K (first) electronic shell. What are the possible values that the (n, ℓ, m_ℓ and m_s) quadruplet can present?

b) Same question for an electron located in a p orbital of the L (second) electronic shell.

3°) One electron owns the following quantum numbers: (3, 2, 2, +½). In which shell and sub-shell is it located? How many quantum boxes exist in this sub-shell?

II. Hydrogen-like system (16 pts)

1°) Give the general relationship that expresses the wavelength of a transition in the **absorption spectrum** for any hydrogen-like system which atomic number is Z. Specify briefly the meaning of any term that appears in this equation.

2°) Represent the energy level diagram for a hydrogen-like system which atomic number is Z. On this scheme, represent the transitions observed during absorption phenomenon having the highest and the lowest energy, respectively.

3°) Express the wavelengths limits for the absorption spectrum observed for a hydrogen-like system as a function of its Rydberg's constant, R_X, and Z. They will be noted λ_m, for the minimum limit and λ_M, for the maximum limit, respectively.

Let's consider two hydrogen-like systems noted as X_1 and X_2, which atomic numbers are Z_1 and Z_2 such that $Z_2 = 2\ Z_1$. In the following part, we will state that their Rydberg's constant R_{X1} and R_{X2} are both equal to the value observed for hydrogen: $R_{X1} = R_{X2} = R_H = 109678\ cm^{-1}$.

4°) What are the numeral values for the following ratios : $\lambda_{m1}/\lambda_{m2}$ and $\lambda_{M1}/\lambda_{M2}$? (The subscripts 1 and 2 refer to hydrogen-like system 1 and 2, respectively)

5°) The value of the wavelength associated to the less energetic transition that appears in the absorption spectrum obtained for X_1 is 13.52 nm. Deduce Z_1 then Z_2.

6°) Establish for both X_1 and X_2 hydrogen-like systems, the relationship for their fundamental state energy as a function of Z_1 and the hydrogen fundamental state energy, noted as $E_f(H)$.

7°) Calculate the ionization energy for X_1, expressed in eV, to within 0.1 eV, then in $kJ.mol^{-1}$. Write this ionization reaction (in other words, define what the reactant and product(s) is/are).

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8°) After exciting a mixture made of the two hydrogen-like systems X_1 and X_2 using a ray which wavelength is $\lambda_e = 10.55$ nm, one obtains an **emission spectrum** presenting a total of 10 lines. This spectrum actually characterizes only one of the two hydrogen-like systems: which one? And why?

9°) Represent in an energy level diagram, all the transitions that are seen in the emission spectrum. Among all of them, calculate the value of the transition presenting the highest wavelength value, in nm to within 1 nm.

Common constants: $h = 6.63\ 10^{-34}$ J.s ; $c = 3\ 10^{8}$ m.s^{-1} ; $e = 1.602.10^{-19}$ C ; $N = 6.02\ 10^{23}$ mol^{-1}