Clémentine CARBON 62 October 15th, 2021

Chemistry 1/2

16.25/20 Very good

5

I. 1. The wavelength and the energy evolve inversly as shown in the equation

$$E = \frac{hc}{\lambda}$$

. The short wavelength limit is thus associated with the highest energy gap meaning from infinity to level n (lowest of the serie)

0.5 level

The long wavelength limit is associated with the lowest energy gap: from level ~~2 to 1~~. n+1 to n (n+1 and n being the lowest level reached)

2. $911,8 \mathring{A} \leq \lambda \leq 1216 \mathring{A}$

$10^{-9}\,m \leq 9,118 \times 10^{-8}\,m \leq \lambda \leq 1,216 \times 10^{-7}\,m \leq 0,5 \times 10^{-6}\,m$

0.25/1

These waves correspond ~~to visible light and~~ ultra violets.

3. λ_{lim} is the long wavelength limit

It corresponds to the transition from ∞ to n

Ritz Balmer formula

$$\frac{1}{\lambda_{\infty \to n}} = Z^2 R_x \left(\frac{1}{(n)^2} - \frac{1}{\infty} \right)$$

$Z = 1$ and $R_x = R_H$ and $\frac{1}{\infty} = 0$

Then $\frac{1}{\lambda_{lim}} = \frac{R_H}{n^2}$

$\Leftrightarrow n^2 = \lambda_{lim} R_H$

$\Leftrightarrow n = \sqrt{\lambda_{lim} R_H}$

$n = \sqrt{911,8 \times 10^{-10} \times 10,9677 \times 10^{7}}$

$n = 1$.

This serie corresponds to transitions toward level 1. ✓

0.75

4. • $E_{\infty \to 1} = |E_1 - E_\infty| = -E_1$ ✓

• $E = h\nu = \frac{hc}{\lambda}$

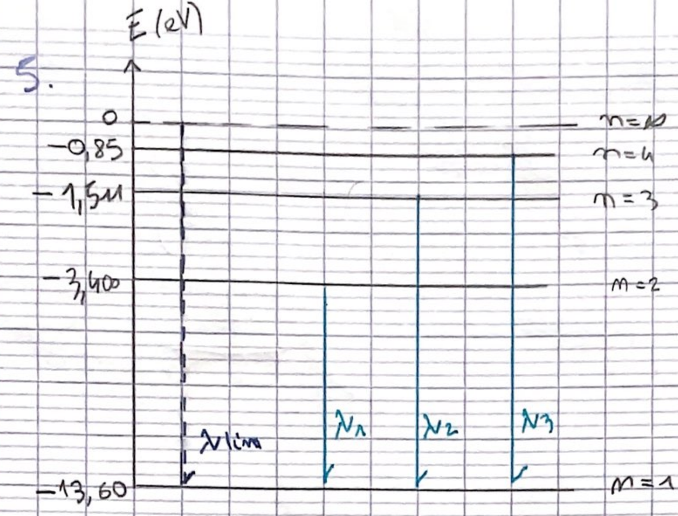
$$E_1 = -\frac{6,626 \times 10^{-34} \times 2,998 \times 10^{8}}{911,8 \times 10^{-10}}$$

$E_1 = -2,179 \times 10^{-18}$ J ✓

$E_1(eV) = \frac{E_1(J)}{e} = \frac{-2,179 \times 10^{-18}}{1,602 \times 10^{-19}} = \underline{-13,60 eV}$ ✓

1

5.



1.5

for each energy level we compute

$$E = \frac{hc}{\lambda} \qquad E_n = -E_{\infty \to n}$$

Ritz Balmer formula

$$\frac{1}{\lambda_{\infty \to n}} = R_H \left(\frac{1}{n^2} - \frac{1}{\infty} \right)$$

1

Thus $E_n = -hc \times R_H \times \frac{1}{n^2}$

$E_1 = -hcR_H$

So $E_n = \frac{E_1}{n^2}$ ✓

$E_2 = -3{,}4\cancel{0}\ eV$ ✓

$E_3 = -1{,}5\cancel{1}\ eV$ ✓

$E_4 = -0{,}85\cancel{00}\ eV$ ✓ significant figures!

6

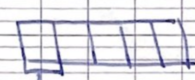
II. a. n is the principal number, it corresponds to the shell it is a non nil integer. ✓
it generally goes up to 5. (maximum 6) ✓

l is the secondary quantum number.
It corresponds to the subshell.
Its value is between 0 and $n-1$
(It generally goes up to 4)

1.0

m_l corresponds to the orbital (magnetic quantum nb) and goes from $-l$ to l.

b. $(n, l, m_l) = (3, 2, -2)$ exists
it corresponds to a 3d subshell



$m_l = -2$

0.75

$(n, l, m_l) = (2, 0, 0)$ exists, it corresponds to a 2s subshell

 $m_l = 0$

$(n, l, m_l) = (2, 3, -3)$ doesn't exist because l can't be greater than n.

2a. $Z = 5$ $A = 11$

$Z = 5$ so the isotope has 5 protons.

0.75

$A - Z = 11 - 5 = 6$ the isotope has 6 neutrons
This isotope is stable it has thus as much electrons as protons. It has 5 electrons.

b. Boron electronic configuration
$1s^2\ 2s^2\ 2p^1$

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2/2.

II 2b. The last full shell is $n=1$ so the valence electrons are contained in the second shell. They are located in 2s and 2p subshells.

0.25

c.

electronic configuration

$\boxed{\uparrow\downarrow}_{2s}$ $\boxed{\uparrow \mid \quad \mid \quad}_{2p}$

$\boxed{\uparrow\downarrow}_{1s}$

0.25

This atom contains one single electron
~~Starting from a total of 5 electron~~

3. An hydrogen-like ion only bears one electron. The Boron element would be written that way (it loses 4 electrons)

0.5

$${}_{5}B^{4+}$$

4. a. $E_i^H = E_{1 \to \infty} = \dfrac{hc}{\lambda_{1 \to \infty}}$

Ritz Balmer formula

$$\frac{1}{\lambda_{1 \to \infty}} = Z^2 R_H \left(\frac{1}{1^2} - \frac{1}{\infty} \right)$$

$$\frac{1}{\infty} = 0 \qquad Z_H = 1$$

$$\frac{1}{\lambda_{1 \to \infty}} = R_H$$

Thus $E_i^H = hc \times R_H$

$$E_i^Z = E_{1\to\infty} = \frac{hc}{\lambda}$$

Ritz Balmer formula

$$\frac{1}{\lambda_{1\to\infty}} = Z^2 R_X \left(\frac{1}{1} - \frac{1}{\infty}\right)$$ v

1

Then $E_i^Z = hc \times Z^2 R_X$ v

$R_X = R_H$ for hydrogen like ions v

Thus $E_i^Z = hcR_H \times Z^2 = E_i^H \times Z^2$ v

b. $E_i^5 = 5^2 \times E_i^H$

$E_i^5 = 5^2 \times 6{,}626 \times 10^{-34} \times 2{,}998 \times 10^8 \times 1{,}09677 \times 10^7$

$E_i^5 = 5{,}447 \times 10^{-17}$ J

$$E_i^5 (eV) = \frac{5{,}447 \times 10^{-17}}{1{,}6 \times 10^{-19}} = 340{,}4 \text{ eV}$$ v

1.5

$E_i^5 (kJ.mol^{-1}) = 5{,}447 \times 10^{-17} \times 10^{-3} \times N_A$

$= 5{,}447 \times 10^{-17} \times 10^{-3} \times 6{,}022 \times 10^{23}$

$= 3{,}280 \times 10^4$ kJ.mol^{-1} v.

5

5,25

III. 1. $E = \frac{hc}{\lambda}$

$$E_A = \frac{6,626 \times 10^{-34} \times 2,998 \times 10^{8}}{101,3 \times 10^{-10}}$$

$E_A = 1,961 \times 10^{-17}\ J$

$= 1,961 \times 10^{-17} \times 10^{-3} \times N_A = 1,181 \times 10^{4}\ kJ.mol^{-1}$ ✓

2

$$E_B = \frac{6,626 \times 10^{-34} \times 2,998 \times 10^{8}}{25,33 \times 10^{-10}} \times 10^{-3} \times N_A$$

$E_B = 4,722 \times 10^{4}\ kJ \cdot mol^{-1}$ ✓

2. Ritz Balmer formula

$$\frac{1}{\lambda_{lim}} = Z^2 R_\infty \left(\frac{1}{1^2} - \frac{1}{\infty}\right)$$

So $Z = \sqrt{\frac{1}{\lambda_{lim} R_\infty}}$

$$\frac{Z_B}{Z_A} = \frac{\sqrt{\frac{1}{\lambda_B R_\infty}}}{\sqrt{\frac{1}{\lambda_B R_\infty}}} = \frac{\frac{1}{\sqrt{\lambda_B}\sqrt{R_\infty}}}{\frac{1}{\sqrt{\lambda_A}\sqrt{R_\infty}}}$$

We simplify

2

$$\frac{Z_B}{Z_A} = \frac{1}{\sqrt{\lambda_B}} \times \frac{\sqrt{\lambda_A}}{1} = \sqrt{\frac{\lambda_A}{\lambda_B}} = \sqrt{\frac{101,3}{25,33}} = 4,99$$

2,000 ✓

→ 3. $E_{B\,4\to 2} = E_{A\,1\to\infty}$

$\Leftrightarrow$ Ritz Balmer: $hc\,R_\infty Z_B^2 \left(\frac{1}{2^2} - \frac{1}{4^2}\right) = hc\,R_\infty Z_A^2 \left(\frac{1}{1} - \frac{1}{16}\right)$

1.25/

$\Leftrightarrow Z_B^2 \frac{3}{16} = Z_A^2$

$\Leftrightarrow \frac{Z_B^2}{Z_A^2} = \frac{16}{3}$

$\Leftrightarrow \frac{Z_B}{Z_A} = \sqrt{\frac{16}{3}} = \frac{4}{\sqrt{3}}$ ✓.

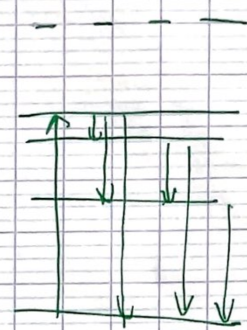
$\frac{Z_B}{Z_A}$ should be equal ~~(or greater)~~ to

(*) equal or (equal or greater.)

$\frac{4}{\sqrt{3}} \simeq 2{,}309 > 2{,}000$

So this condition isn't fulfilled.

II.5. If the emission spectrum contains 6 rays, the electron of the B^{4+} hydrogen-like ion has first been excited to level $n=4$



the frequency band should permit a transition de $n=1$ à $n=4$ (minimum value)

not allow transition from $n=1$ to $n=5$

max frequency

$$\nu_{1-5} = \frac{c}{\lambda} = cR_H Z^2 \left(\frac{1}{1^2} - \frac{1}{5^2}\right)$$

$7,890 \times 10^{16}$ Hz

$\nu < \nu$