INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON PCC, Amerinsa, Asinsa, SCAN – 1^{st} Year *October 6th 2017*

CHEMISTRY 1 – Test n°1 - Duration : 1 hour

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

Answers must be justified.

Results must be given with the appropriate number of significant digits.

The 3 exercises are independent.

Data :

Rydberg's constant for Hydrogen: $R_H = 109677\ cm^{-1}$

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

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

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

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

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

Kinetic Energy: $E_k = 1/2\ mv^2$

Element	$_1H$	$_6C$	$_7N$	$_8O$
M ($g.mol^{-1}$)	1.01	12.0	14.0	16.0

Density of water: 1.00 $g.cm^{-3}$

Density of octane: 0.70 $g.cm^{-3}$

Molar volume of ideal gas in standard conditions = 22.4 $L.mol^{-1}$

Exercise 1: Combustion of gasoline (approximate scale of mark 5 pts)

Liquid octane (C_8H_{18}) can undergo a total combustion to give liquid water and gaseous carbon dioxide. All gases will be considered as perfect gases.

a) Write down the equation of octane (C_8H_{18}) combustion.

b) Starting with one mole of octane and a large excess of dioxygen:

   i) Compute in g the mass of CO_2 produced.

   ii) Compute in mL the maximum volume of liquid water that will be produced.

c) Compute in L the volume of CO_2 produced when starting with 100 mL of octane and $1m^3$ of dioxygen.

d) Let's consider a liquid mixture (of density 0.75 $g.cm^{-3}$) made of non-flammable compound (5 weight %) and octane (95 weight %). The combustion of one liter of such mixture produces $1m^3$ of CO_2: compute the yield of the reaction.

Exercise 2: Hydrogen spectroscopy (approximate scale of mark 7 pts)

a) Give the definition of the ionization energy of hydrogen. Which data from the absorption spectrum allow the determination of its value?

b) Which phenomenon is observed during the transition of the electron from the excited state to the ground state?

c) From Balmer's formula, in the case of hydrogen

i) Establish the expression of the energy E_n for a level n, as a function of E_1 and n (justify).

ii) Compute E_1, first in J and then in eV to within 0.01 eV.

iii) Give the energy values E_2, E_3, E_4, E_5 and E_6 to within 0.01 eV.

d) Represent the corresponding complete Grotrian's diagram.

e) Give the electromagnetic radiation frequency (in Hz) required for obtaining an excitation of the electron up to level n=6.

f) How many rays will then be observed on its corresponding emission spectrum? Indicate them on the diagram (question d).

Exercise 3: Study of a hydrogen like ion (approximate scale of mark 7.5 pts)

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 electron and converted into kinetic energy.

Irradiation by photons of wavelength λ_0=1.420 nm of a hydrogen like ion X extract an electron with a 1.78×10^6 $m.s^{-1}$ speed. We will consider $R_X = R_H$.

a) Give first the literal expression **and then** compute the ionization energy of the hydrogen like ion X in Joules **and** in eV.

b) Show that this hydrogen like ion is obtained from oxygen. Give its formula.

We will consider the emission spectrum obtained after an irradiation with an electromagnetic radiation of energy comprised between 864 and 866 eV.

c) Which maximum level can be reached after this excitation?

d) On the emission spectrum, a ray of wavelength λ_1 comprised between 400 and 450 nm is observed.

i) To which electromagnetic domain does it correspond to?

ii) Determine the transition corresponding to this ray.

iii) Compute in eV the energy of the emitted photon.