Ministry of Higher Education and Scientific Research
Salah Boubnider University, Constantine 3
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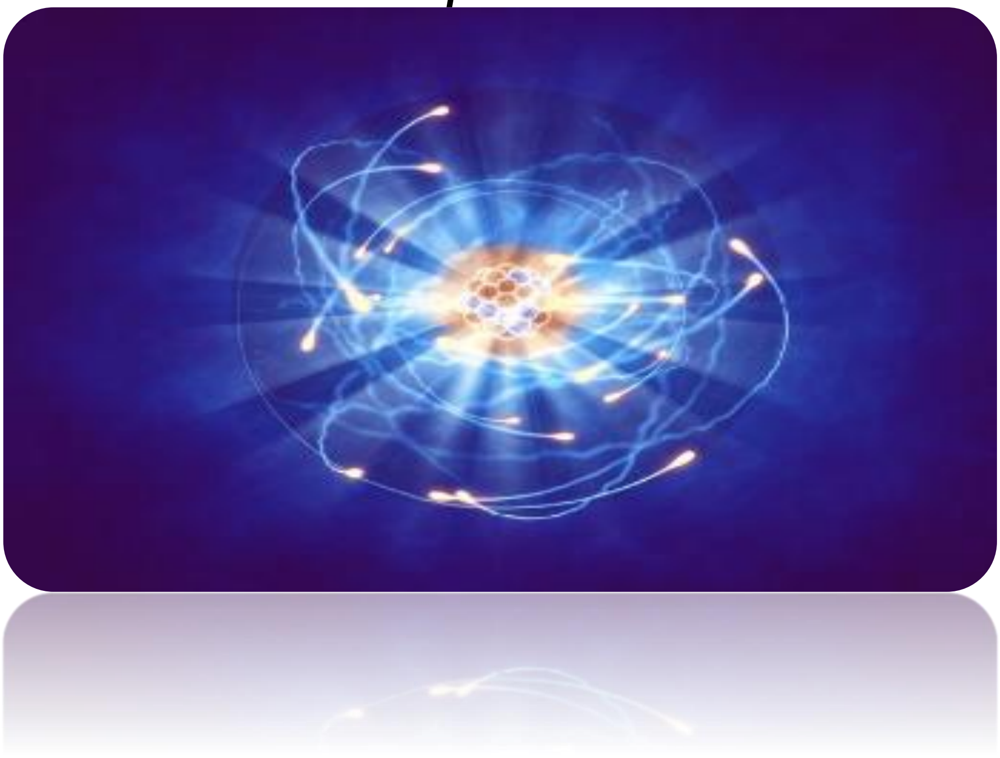
Tutorials and MCQ

Structure of Matter & Chemical Bonds

MCQ

General and Organic Chemistry

First Year of Dental Medicine



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Foreword

This work is primarily intended for first-year students of Medical studies (Dental Medicine, Medicine and Pharmacy). It is also intended for all undergraduate students and and preparatory classes whose training includes general chemistry.

This book is divided into two main parts covering all topics addressed in chemical atomistics. The first part is dedicated to directed work exercises with detailed solutions for the different topics covered in the atomistics section, namely: structure of matter, structure of the atom, electronic structure of the atom, the periodic classification of chemical elements, and finally chemical bonding. The second part includes a number of MCQs related to the topics covered in lectures and directed work. Finally, the third part deals with general chemistry synthesis exam MCQs.

The students will find in this book an excellent way to assess their knowledge and practice multiple-choice questions to enhance efficiency and speed in thinking and problem-solving, which will allow them to prepare optimally for the exam day.

We have drawn on our experience as university teachers to develop a support tool that is as comprehensive and educational as possible.

Dr. Atmani -Merabet Ghania

Used Symbols, Notations, and Constants

Nouns	***Symbols***	***Values***
Avogadro's number	N	$6.023\ 10^{23}$
Planck's constant	H	$6.62\ 10^{-34}$ J s
Rydberg's constant	Rh	$1.1\ 10^{7}$ m^{-1}
Elementary charge	E	$1.6\ 10^{-19}$ coulombs
Light speed	C	$3\ 10^{8}$m/s
Electron- volt	eV	eV = $1.602\ 10^{-19}$ J

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Introduction

General chemistry is one of the fundamental pillars of scientific training for students in medicine, pharmacy, and health sciences. It provides the essential foundations for understanding biological, biochemical, and medical phenomena, and prepares students to confidently approach the specialized disciplines of their curriculum. Among the various branches of chemistry, atomistics occupies a central place: it enables the comprehension of the intimate structure of matter, the properties of elements, and the principles that govern their interactions.

This course book has been designed as a tool for guidance and practice. It offers a structured progression that meets the needs of first-year students and those in preparatory classes:

- A first part devoted to tutorial exercises, with detailed solutions that allow step-by-step understanding of reasoning and problem-solving methods.
- A second part consisting of targeted multiple-choice questions (MCQs), aimed at testing knowledge and strengthening speed of thought.
- A third part made up of synthesis exam questions, giving students the opportunity to practice under conditions similar to real assessments.

Beyond practice, this document aims to develop essential skills:

- The ability to analyze and solve scientific problems with rigor.
- The acquisition of methodological reflexes useful for examinations.
- Self-confidence when facing evaluation situations.

We hope that this coursebook will serve as a daily companion for each student, promoting the progressive assimilation of concepts and optimal preparation for exams. It is part of a pedagogical approach that values autonomy, regular practice, and efficiency.

Difficulty Levels Legend

Symbol	Level	Description
*	Easy	Direct application of the course, basic concepts
**	Intermediate	Combination of several concepts, requires reasoning
***	Advanced	Complex exercises, cross-disciplinary or similar to exam questions

Tutorial 1

(The constituents of the atom)

Exercise n°1 *

a) Give in grams the mass of:

- $3{,}62\ 10^{24}$ atoms of zinc (Zn : 65,37)

- $6{,}02\ 10^{21}$ molecules of H_2O (H : 1, O : 16)

b) Calculate the number of moles of glucose. ($C_6H_{12}O_6$) in 21,6 g de $C_6H_{12}O_6$. (C : 12)

c) The iron atom (Fe) has an atomic mass of 56g, what is the mass of an iron atom in grams and in (amu).

d) Indicate the number of protons, neutrons, and electrons for : ${}^{9}_{4}Be$ ${}^{27}_{13}Al^{3+}$ ${}^{32}_{16}S^{2-}$

e) Let the aluminum nucleus (${}_{13}Al$). Give its mass in (Kg), its volume in (m^3) and its density in (Kg/m^3).

Exercise n°2**

Calculate the number of electrons of a nucleus X, with a mass number A = 10. Given that the experimental mass of the nucleus is: 10.020166 amu and that the binding energy per nucleon is : $8\ 88693\ 10^{-13}$joules. (mp = 1.007278 amu ; mn = 1.008665 amu)

Exercise n°3 *

The natural carbon element (C = 12.011) is a mixture of two stable isotopes : ${}^{12}C$, ${}^{13}C$ knowing that the abundance of ${}^{12}C$ est 98.89 %, calculate the atomic mass of the isotope

Exercise n°4 *

1- A sample of copper oxide CuO has a mass of m= 1.59g. How many moles and molecules of CuO are there? Then calculate the number of Cu and oxygen atoms in this sample. [M_{Cu} = 63.54g ; M_O= 16g]

2- Let's consider the calcium atom, which has an atomic mass of 40 g. Give the mass of this atom in grams and in amu.

3- Give the number of protons, electrons, and neutrons for : ${}^{40}_{20}Ca$ ${}^{40}_{20}Ca^{2+}$ ${}^{35}_{17}Cl$ ${}^{35}_{17}Cl^{-}$

4- Calculate for the ${}^{24}Mg$ nucleus: its mass in Kg, its volume in m^3 and its density in Kg/m^3

Exercise n°5* *

Let us consider the nitrogen nucleus. $^{14}_{7}N$, calculate the theoretical mass of this nucleus in amu. Compare it with its actual value of 14.00751 amu.

Calculate cohesion energy of this nucleus in en Joules and MeV.

Data : mass proton = 1.007277 amu mass neutron = 1.008665 amu

***Exercise n°6* ***

The natural element silicon Si (Z=14) is a mixture of three stable isotopes.: ^{28}Si, ^{29}Si et ^{30}Si. The natural abundance of the most abundant isotope is 92.23%. The atomic mass of natural silicon is 28.085g.

1- Which isotope is the most abundant?

2- Calculate the natural abundance of the other two isotopes.

***Exercise n°7* ***

a) Give the number of moles of $MgSO_4$ in 40,1g.

b) Calculate the mass in grams of 3.62×10^2 zinc atoms..

c) How many carbon and oxygen atoms are there in 0.6 moles of

d) Consider the NaCl molecule with a molecular mass of 58.5 g. Give the mass of this molecule in amu and in grams.

e) Indicate the number of protons, electrons and neutrons:

$^{24}_{12}\mathbf{Mg}$ $^{298}_{92}\mathbf{U}$ $^{40}_{20}\mathbf{Ca}^{2+}$ $^{16}_{8}\mathbf{O}^{2-}$

Exercise n° 8*

Distinguish among the following compounds the mixtures of pure substances : H_2O, air, sand, NaOH, CH_3COOH, F_2, CH_3COOH solution, diamond, carbon, mineral water, milk, blood.

Exercise n°9*

1- How many moles are there in 40.1 g of $MgSO_4$.

2- How many grams are there in 0.4 moles of $CaCO_3$.

3- Calculate the mass in grams of 3.62 10^{24} atoms of zinc(Zn) and 6.02 10^{21} H_2O molecules.

4- How many grams of CO_2, and CO_2 molecules, and carbon and oxygen atoms are there in 0.6 moles of CO_2 ?

Data : H : 1 ; C : 12 ; O : 16 ; Mg : 24 ; S : 32 ; Ca : 40 ; Zn : 65,39

Exercise n°10*

Consider the copper atom (Cu), which has an atomic mass of 63 g. Give the mass of this atom in amu and in grams.

Consider the sodium chloride molecule NaCl, which has a molecular mass of 58.5 g. Give the mass of this molecule in amu and in grams.

Exercise n°11**

Hemoglobin is a macromolecule with a molecular mass of approximately 18.000. One cubic millimetre (1 mm^3) of blood contains approximately 5×10^6 (5 million) red blood cells and a total hemoglobin mass of 0.15 mg. How many hemoglobin molecules are there in one red blood cell?

Data : Mg = 24g S= 32g O= 16g Ca = 40g C = 12g Zn = 65,37g

Exercise n°12*

1- What is the number of protons present in an atom with atomic number Z.

2- What is the number of protons and electrons in atoms : ${}^{24}_{12}Mg$ ${}^{238}_{92}U$

3- What is the number of protons and electrons in ions : ${}^{40}_{20}Ca^{2+}$; ${}^{16}_{8}O^{2-}$, ${}^{35}_{17}Cl^{-}$

4- Carbon contains two isotopes ${}_{12}C$ et ${}_{13}C$, with respective masses of 12 and 13.0034. Given that the average mass of carbon is 12.011g. Give the percentage of each isotope.

5- Classify the following elements according to isotopes, isobars and isotones.

${}^{16}_{8}O$, ${}^{14}_{7}N$, ${}^{12}_{6}C$, ${}^{12}_{5}B$, ${}^{13}_{6}C$, ${}^{15}_{8}O$, ${}^{13}_{7}N$, ${}^{17}_{8}O$, ${}^{19}_{9}F$, ${}^{18}_{9}F$, ${}^{15}_{7}N$

Exercise n°13*

What is the chemical symbol for the element whose isotope nucleus contains 18 protons and 22 neutrons?

Exercise n° 14****

The mass of copper in the Statue of Liberty in New York is 2.5×10^5 kg. What is the total mass of the electrons in this statue?

Exercise n°15***

Calculate the mass of nickel contained in 2.5 g of nickel sulphate hexahydrate. $NiSO_4.6H_2O$

Tutorial 1 Solutions

Exercise n°1

a) 1 mole (Zn) : 65.37 g $\longrightarrow$ N atoms

x (g) $\longrightarrow$ $3.62\ 10^{24}$ atoms

La masse du zinc :

$$x = \frac{65.37 \times 3.62\ 10^{24}}{6.023\ 10^{23}} = 392.89 \text{ g}$$ ***The mass of zinc* = *392.89 g***

1 mole (H_2O) : 18 g $\longrightarrow$ $6.023\ 10^{23}$ molecules

x (g) $\longrightarrow$ $6.02\ 10^{21}$molecules

La masse de H_2O :

$$y = \frac{18 \times 6{,}02\ 10^{21}}{6{,}023\ 10^{23}} = 0.179 \text{ g}$$ ***The mass of H_2O = 0.179 g***

b) Number of moles of glucose: $M(C_6H_{12}O_6) = 6 \times 12 + 12 \times 1 + 6 \times 16 = 180$ g

1 mole (glucose) $\longrightarrow$ 180 g

x mole $\longrightarrow$ 21.6 g

$$x = \frac{21.6}{180} = \mathbf{0.12\ moles}$$

c) The atomic mass of Fe = 56 g, which is the mass of one mole of Fe. The mass of one atom of Fe is therefore 56 uma, and the mass of the iron atom in grams is:

$56 \times 1.66\ 10^{-24} = \boldsymbol{9.29\ 10^{-23}\ g}$

[note that : 1 amu = $1.66\ 10^{-24}$ g = $1.66\ 10^{-27}$ kg et 1 amu = $\frac{1}{N}$ g]

d) ${}^{9}_{4}Be$: $\begin{matrix} A = 9 \\ Z = 4 \end{matrix} \begin{cases} A = n + p \\ Z = e^- = p \end{cases}$ therefore $\begin{matrix} protons = 4 = e^- \\ neutrons = A - P = 5 \end{matrix}$

${}^{27}_{13}Al^{3+}$: aluminium has lost $3e^-$ therefore : protons = 13, e^- = 10, neutrons = 27 – 13 = 14

${}^{32}_{16}S^{2-}$: sulphur has won $2e^-$ therefore : $\begin{matrix} protons = 16 \\ e^- = 19 \end{matrix}$, neutrons = 32 – 16 = 16

e) $^{27}_{13}Al$ (nucleus) : ***the mass of the nucleus*** = A = 27 uma = 27 x 1.66 10^{-27} kg = ***4.482 10^{-26} kg***

The relationship of the volume of the nuclei: $V = \frac{4}{3}\pi R^3$

The radius : $R = R_0 . A^{1/3}$ $[R_0 = \sqrt{2}\ fermis = \sqrt{2}10^{-15}m\ ]$

$R = 1.414\ 10^{-15}(27)^{1/3}$ Therefore ***$R = 4.2419\ 10^{-15}$ m***

Volume of the nucleus: $V = \frac{4}{3}\pi\ R^3 = \frac{4}{3}\pi\ (4.2419\ 10^{-15})^3$ Therefore ***$V = 3.21\ 10^{-43}\ m^3$***

The density of the nucleus: $\rho = \frac{m}{v} = \frac{4.482\ 10^{-26}}{3.21\ 10^{-43}}$ Therefore

$$\begin{cases} \rho = 1.39\ 10^{17}\ kg/m^3 \\ \rho = 1.39\ 10^{14}\ g/cm^3 \end{cases}$$

That is to say, the nuclei are microscopic; indeed, a nucleus with a volume of $1cm^3$ contains a mass of ***1.39 10^{14} g.***

Exercise n°2

Nucleus $^{A}_{X}Z$: A = 10, we are looking for the number of electrons: Z

a = 8.88693 10^{-13} joules/ nucleons and m_{exp} = 10.020166 amu

$a = \frac{\Delta E}{A}$ (Mev/nucleons) $\Rightarrow$ $\Delta E = a \times A$

We have : 1 eV $\longrightarrow$ 1.6 10^{-19} joules

x $\longrightarrow$ 8.88693 10^{-13} Joules

Therefore x = a = 5.55 10^6 ev a = 5.55 Mev/nucleons So : $\Delta E = a \times A = 5.55 \times 10$

The binding energy ΔE = 55.5 Mev further more we have : ***ΔE(Mev) = Δm (amu) x 931***

Therefore ***The mass defect Δm = 0.059613 amu***

Δm = theoretical mass - experimental mass = [Zmp + (A-Z)mn] – exp m

Δm + expm = Z (mp - mn) + Amn

$$\frac{\Delta m + expm - Amn}{mp - mn} = Z$$

$$Z = \frac{0.059613 + 10.020166 - 10\,(1.008665)}{1.007278 - 1.008665}$$ Therefore:

Z = 4.95 $\Rightarrow$ ***Z* = 5** This is the element Boron.

Exercise n°3

We have the isotopes ${}^{12}_{6}C$ (98.89 %) and ${}^{13}_{6}C$

$\bar{M}$= 12.011 g, we are looking for the atomic mass of ^{13}C

$$\bar{M} = \frac{x1m1 + x2m2}{100}$$ with $m_1 = 12$, $x_1 = 98.89\%$, $m_2 = ?$ et $x_2 = 100 - 98.89 = 1.11\ \%$

$$\frac{\bar{M} \times 100 - x1m1}{x2} = m_2$$

The isotope mass ***^{13}C :***

$$m_2 = \frac{12.011 \times 100 - (98.89 \times 12)}{1.11} = 12.99 \cong \boldsymbol{13}$$

Exercise n°4

1) ***The number of moles of CuO*** :

1 mole $\longrightarrow$ 63.54 + 16 = 79.54 g

x $\longrightarrow$ 1.89 moles therefore $x = \frac{n}{M}$ = ***0.019 moles of CuO***

The number of molecules of CuO :

1 mole de CuO $\longrightarrow$ N molecules

0.019 moles $\longrightarrow$ y therefore ***y* = 1.14 10^{22} molecules de CuO**

The number of copper and oxygen atoms:

1 molecule of CuO $\longrightarrow$ 1 atom of Cu et 1 atom of oxygen

1.14 10^{22} molecules $\longrightarrow$ *1.14 10^{22} atoms of Cu* and *1.14 10^{22} atoms of oxygen*

2) ***The mass of a calcium atom in grams:***

The atomic mass of calcium = 40 g, the mass of a Ca atom will be 40 amu, therefore the mass of a calcium atom in grams is : 40 x 1.66 10^{-24} = ***6.64 10^{-24}g***

3)

Element	*Protons*	*Electrons*	*Neutrons*
${}^{40}_{20}Ca$	20	20	20
${}^{40}_{20}Ca^{2+}$	20	18	20
${}^{35}_{17}Cl$	17	17	18
${}^{35}_{17}Cl^{-}$	17	18	18

It should be noted that ${}^{A}_{Z}X$: Z = protons = electrons A – Z = Neutrons

Formation d'un cation : X $\longrightarrow$ X^{+} + $1e^{-}$ **Cation**

Formation of an anion : X + $1e^{-}$ $\longrightarrow$ X^{-} **Anion**

4) ^{24}Mg : mass of the nucleus Mg = 24 amu

Mass of the nucleus Mg = 24 x 1.66 10^{-27}

Mass of the nucleus Mg = 3.984 10^{-26} kg

Volume of the nucleus: *nucleus = sphere* : $V = \frac{4}{3}\pi R^3$

$R = R_0 A^{1/3} = 1.414\ 10^{-15}\ (24)^{1/3}$

$R = 4.078\ 10^{-15}$ m $\Rightarrow$ ***V= 2.84 10^{-43} m^3***

Volumetric mass of the nucleus: $\rho = \frac{m}{V} = \frac{3.984\ 10^{-26}}{2.84\ 10^{-43}}$ Therefore :

ρ = 1.40 10^{17} kg/m^3

$\rho = 1.40\ 10^{20}$ g $10^{-6}/cm^3$

ρ = 1.40 1 0^{14} g/cm^3

It's a huge mass in a small volume.

Exercise n°5

The nucleus of nitrogen : ${}^{14}_{7}N$

1) *The theoretical mass*: mth = Zmp + (A – Z) mn

thm = 7 x 1.007277 + 7 x 1.008665 = 14.111594 amu ; Therefore :

thm = 14.111594 amu

theoretical mass > real mass

2) *The cohesion energy ΔE :*

$\Delta E = \Delta m\ c^2$

The mass defect Δm : Δm = thm – realm

Δm = 0.104079 amu

We remind you that: ΔE (joules) : $\underset{(Joules)}{\Delta E} = \underset{(kg)}{\Delta m}\ \underset{(m/s)}{c^2} = \Delta m\ (amu) \times 14{,}94\ 10^{-11}$

$\Delta E = 0.104079 \times 14.94\ 10^{-11} = 1.55\ 10^{-11}$ joules therefore ***$\Delta E = 1.55\ 10^{-11}$ joules***

ΔE(Mev) = Δm (amu) x 93 = 96.89 Mev therefore ***ΔE(MeV) = 96.89 Mev***

3) ***The binding energy per nucleon***:

$$a = \frac{\Delta E}{A} = \frac{96.89}{14} = 6.92\ \text{MeV /nucleons}$$

Exercise n°6

$^{28}_{14}Si$, $^{29}_{14}Si$, $^{30}_{14}Si$ / $\overline{M}$ = 28.085 g

1) The most abundant isotope is $^{28}_{14}Si$ because the atomic molar mass of Si is 28,085 g.

2) The abundance of the other isotopes

The abundance de $^{29}_{14}Si \longrightarrow x_2$ $\%^{28}_{14}Si = 92.23\%\ (x_1)$

The abundance *de* $^{30}_{14}Si \longrightarrow x_3$

$\overline{M} = x_1m_1 + x_2m_2 + x_3m_3 / 100$

(1) $28.085 = 92.23\ (28) + x_2 \times 29 + x_3 \times 30 / 100$

Moreover, we have : $92.23 + x_2 + x_3 = 100$

$x_2 + x_3 = 100 - 92.23 = 7.77$ therefore

$x_2 = 7.77 - x_3$

From the relationship **(1)** : $2808.5 = 2582.44 + 29\ (7.77 - x_3) + 30\ x_3$

Finally ***: $x_3 = 0.73\%$*** et $x_2 = 7.77 - 0.73$ therefore

$x_2 = 7.04\%$

Exercise n°7

a) ***The number of moles of $MgSO_4$*** : 1 mole $MgSO_4 \longrightarrow$ 120 g

x $\longrightarrow$ 40.1 g

Therefore ***x = 0.33 moles***

b) ***The mass of 3.62 10^{24} atoms of Zn*** :

1 mole de Zn $\longrightarrow$ 65.37 g $\longrightarrow$ N atoms

x(g) $\longrightarrow$ 3.62 10^{24} atoms

$$x = \frac{65.37 \times 3.62\ 10^{24}}{6.023\ 10^{23}} = \mathbf{39.89\ g}$$

c) ***The number of moles of CO_2*** : We have : 1 mole CO_2 $\longrightarrow$ N molecules of CO_2

0.6 moles $\longrightarrow$ X molecules

X = 0.6 6.023 10^{23} = ***3.61 10^{23} molecules of CO_2***

* 1 molecule of CO_2 $\longrightarrow$ 2 atoms of oxygen

3.61 10^{23} molecules of CO_2 $\longrightarrow$ X_1 atoms of oxygen

X_1 = 2 x 3.61 10^{23} = 7.22 10^{23} atoms of oxygen

* 1 molecule of CO_2 $\longrightarrow$ 1atom of carbon

3.61 10^{23} molecules of CO_2 $\longrightarrow$ X_2 atoms of carbon

X_2 = 3.61 10^{23} atoms of carbon.

d) The molecular mass of NaCl = 58.5 g ; therefore the mass of a molecule of NaCl will be : 58.5 amu

We know that 1 amu $\longrightarrow$ 1.66 10^{-24}g

58.5 amu $\longrightarrow$ y

y = 9.7 10^{-23} g (mass of a molecule of NaCl)

e) $^{24}_{12}Mg$: Z = 12 = p = e^- number of neutrons = 12

$^{238}_{92}U$: Z = 92 = p = e^- neutrons = 146

$^{40}_{20}Ca^{2+}$: p = 20 number d'e^- = 18

$^{35}_{17}Cl^-$: p = 17 e^- = 18 A + 1 e^- $\longrightarrow$ A^-

B $\longrightarrow$ B^+ + 1 e^-

Exercise n°8

Simple pure substance	***Compound pure substance***	***Homogeneous substance***	***Heterogeneous substance***
F_2	H_2O	Air	Sand
Diamond	NaOH	CH_3COOH Solution	Blood
Carbon	CH_3COOH	Mineral water, Milk	

Exercise n°9

1) 1 mole de $MgSO_4$ $\longrightarrow$ 120 g

x $\longrightarrow$ 40.1 g

Therefore ***x = 0.33 moles (The number of moles of $MgSO_4$)***

2) 1 mole de $CaCO_3$ $\longrightarrow$ 100 g

0.4 moles $\longrightarrow$ x (g)

Therefore ***x = 40 g(mass of $CaCO_3$)***

3) 1 mole of Zn $\longrightarrow$ N atoms

x $\longrightarrow$ 3.61 1024 atoms

Therefore ***x = 6,01 moles (number of molse of Zn)***

1 mole of Zn $\longrightarrow$ 65.37 g

6.01 moles $\longrightarrow$ y

Therefore ***y = 392,89 g(masse of zinc)***

1 mole of H2O $\longrightarrow$ N molecules $\longrightarrow$ 18 g

6.02 1021 molecules $\longrightarrow$ x

Therefore ***x = 0.18 g(mass of H_2O)***

4) 1 mole of CO_2 $\longrightarrow$ 44 g

0.6 moles $\longrightarrow$ x_1

x_1 = 26.4 g(mass of CO_2)

1 mole of CO_2 ——— N molecules of CO_2

0.6 moles ——— x_2

x_2 = 3.61 10^{23} molecules of CO_2

1 molecule of CO_2 $\longrightarrow$ 1 atom carbon

3.61 10^{23} molecules $\longrightarrow$ ***x_3 = 3.61 10^{23} atoms of carbon***

1 molecule of CO_2 ⟶ 2 atoms of oxygen

$3.61 \; 10^{21}$ molecules ⟶ ***$x_4 = 7.22 \; 10^{23}$ atoms of oxygen***

Exercise n°10

1 mole of Cu ⟶ N atoms ⟶ 63 g

1 atom ⟶ x

The mass of the atom of Cu is : $x = \frac{63}{N}$ g = ***63 amu***

x = 63 amu et 1 amu = $1.66 \; 10^{-24}$ g

Therefore ***The mass of the atom of Cu in [g] :*** $63 \times 1.66 \; 10^{-24}$ = ***$1.045 \; 10^{-22}$ g***

The molecular mass of NaCl is 58.5 g, therefore the mass of one molecule of NaCl is 58.5 amu and it is:

$58.5 \times 1.66 \; 10^{-24}$ = ***$9.71 \; 10^{-23}$ g***

Exercise n°11

We have 1 mole of hemoglobin ⟶ N molecule of hemoglobin ⟶ 18000 g

x molecules of hemoglobin ⟶ $0.15 \; 10^{-3}$ g

x = ***$5.019 \; 10^{15}$ molecules of hemoglobin***

x mole of hemoglobin in 1 mm3 of blood and in $5 \; 10^{6}$ of red blood cells

Therefore : $5 \; 10^{6}$ red blood cells ⟶ $5.019 \; 10^{15}$ molecules of hemoglobin

1 red blood cell ⟶ y

$y = 1.0038 \; 10^{9}$ molecules of hemoglobin.

In 1 red blood cell, we have 1 billion hemoglobin molecules..

Exercise n°12

1) Z = atomic number = number of protons = number of electrons, Therefore the number of protons in an atom with atomic number Z is Z protons

2) $^{24}_{12}Mg$ **: *Z = 12 = p = e-***

A = 24 = N + Z ⟹ N = A – Z = 24 – 12, Therefore : ***N = 12 neutrons***.

$^{238}_{92}U$: **Z = 92 = p = e-**

A = 238 et N = 238 – 92 = ***146 neutrons***

3/ $^{40}_{20}Ca^{2+}$: A $\longrightarrow$ A^{+} + 1 e- et A + 1e- $\longrightarrow$ A^{-}

$^{40}_{20}Ca^{2+}$: Z = 20 = p e- = 18

$^{16}_{8}O^{2-}$: Z = 8 = p e- = 10

$^{35}_{17}Cl^{-}$: Z = 17 = p e- = 18

4) $\overline{M} = \sum \frac{ximi}{100}$ $\sum xi$ = 100

12,011 = $\frac{12\ x1 + 13.0034\ x2}{100}$

x1+x2 = 100 x1 = 100 – x2

12.011 100 = 12 (100 – x2) + 13.0034 x2

120.1 = 1200 + x2(13,0034 – 12) Therefore :

x2 = $\frac{1.1}{1.0034}$ $\begin{cases} x2 = 1.096\ \% \\ x1 = 98.904\ \% \end{cases}$ Therefore *^{12}C (98.904%) et ^{13}C (1.096%)*

5) Reminder:

Isotopes: are elements that have the same Z and different A

Isobars: are elements that have the same A and different Z different

Isotones: are elements that have the same number of neutrons

Isotopes	*Isobars*	*Isotones*
$^{15}_{8}O\ ^{16}_{8}O\ ^{17}_{8}O$	$^{15}_{8}O\ ^{15}_{7}N$	$^{15}_{8}O\ ^{14}_{7}N\ ^{12}_{5}B$ (n = 7)
$^{12}_{6}C\ ^{13}_{6}C$	$^{12}_{6}C\ ^{12}_{5}B$	
$^{15}_{7}N\ ^{14}_{7}N\ ^{13}_{7}N$	$^{17}_{8}O\ ^{17}_{9}F$	$^{16}_{8}O\ ^{17}_{9}F\ ^{15}_{7}N$ (n = 8)
$^{17}_{9}F\ ^{18}_{9}F$		$^{17}_{8}O\ ^{18}_{9}F$ (n = 9)
		$^{12}_{6}C\ ^{13}_{7}N$ (n = 6)

Exercise n°13

The element for which the atomic number Z = 18 is argon. The chemical symbol associated with the atomic number and the mass number A = 18 + 22 = 40 est $^{40}_{18}Ar$.

Exercise n°14

The atomic mass of copper is 63.5 g and its atomic number is 29.

The number of copper atoms corresponding to the mass of the Statue of Liberty, that is *(2.5 10^5 kg)* *(2.5 10^8 g)* will be :

$$2.5 \cdot 10^8\, g \cdot \frac{6.022 \cdot 10^{23}\, atoms\, mol^{-1}}{63.5\, g\, mol^{-1}} = \mathbf{2.37 \cdot 10^{30}\, atoms}$$

Each copper atom contains 29 electrons, therefore the number of electrons present in the Statue of Liberty is :

$$2.37 \cdot 10^{30}\, at \cdot 29\, electrons = \mathbf{6.87 \cdot 10^{31}\, electrons}$$

Since the mass of an electron is $9.109 \cdot 10^{-28}$ g, the total mass of the electrons in the Statue of Liberty will therefore be :

$$6.87 \cdot 10^{31} \cdot 9.109 \cdot 10^{-28} = \mathbf{6.26 \cdot 10^4\, g \quad ou\; 62.6\; kg}$$

Exercise n°15

The molar mass of $NiSO_4 \cdot 6H_2O$:

M = $58.693 + 32.066 + 4 \cdot 15.999 + 6 \cdot 18.015 = \mathbf{262.85\, g\, mol^{-1}}$

The number of moles of Ni in 2.5 g of $NiSO_4 \cdot 6H_2O$:

$$n_{Ni} = \frac{2.5}{262.85\, g\, mol^{-1}} = \mathbf{9.51 \cdot 10^3\, moles}$$

The mass of Nickel is :

$$m_{Ni} = 9.51 \cdot 10^{-3}\, mol \cdot 58.69\, g\, mol^{-1} = \mathbf{0.558\, g}$$

Tutorial 2

(The nucleus and radiation)

Exercise n°1*

The wavelength λ of sodium vapour is given as 5900 A°, , the speed of light c = 3 10^8 m/s and Planck's constant h= 6.62 10^{-34}J S.

Calculate :

a) The associated wave number in m^{-1}.

b) The frequency of the wave.

c) The energy of the emitted photon.

Exercise n°2***

a) If a hydrogen atom in its ground state absorbs a photon with a wavelength λ_1 equal to 972.8 A° and then emits a photon with a wavelength λ_2 equal to 18790 A°, what energy level will the electron be in after this emission?

b) Represent the two transitions corresponding to these two lines on an energy diagram.

c) Calculate the ionisation energy from the ground state. Given: R_H = 1,1 10^7 m^{-1}

Exercise n°3***

Let λ = 57.3 A° be the shortest wavelength in the spectrum of a Be^{3+} hydrogenoid (Z = 4).

a) What is this transition and calculate the corresponding energy.

b) Calculate the wavelength relative to the same transition for a hydrogen atom and deduce its energy.

c) Plot on an energy diagram:

(a) The 3^{rd} Lyman absorption line.

(b) The 1^{st} Paschen emission line.

(c) The 3^{rd} Balmer emission line.

***Exercise n°4** ***

The electron of the hydrogen atom in its ground state is excited with energies equal to 10.20, 12.08 and 12.74 eV.

1) Determine the energies of the electron in the ground state at the different levels.

2) Specify the diagram and the associated energy. Which series of absorptions is this?

3) What is the wavelength of each transition?

Data : c = 3 10^{8} m/s   h = 6.62 10^{-34}J s. Ei = 13.6 eV

Exercise n°5*

Given the Li $^{+2}$ 2 ion, calculate the third ionisation energy of lithium in joules and eV, and calculate the wavelength and frequency of the line corresponding to the transition
n= 4 $\rightarrow$ n= 1.

Exercise n°6 **

1- The electron of a hydrogen atom initially at level n= 3 emits radiation with a wavelength λ= 1027 A°. At what level is the electron?

2- The absorption of a photon with wavelength λ = 64 A° by a hydrogenoid X in its ground state releases an electron with kinetic energy equal to 71 eV. Determine the atomic number Z of this hydrogenoid.

Exercise n°7*

Consider electromagnetic radiation with a wavelength of 5000A°. Calculate the energy carried by this radiation in joules and kilocalories, as well as the corresponding wave number.
Given: 1Cal = 4.18 joules

Exercise n°8 *

Bohr's theory is applied to the electron of the hydrogen atom, which is characterised by n = 3.
Calculate:

1- The radius of this orbit in A°.
2- The energy of the electron in eV.
3- The ionisation energy from n = 3.
4- The wavelength in A° corresponding to transitions 3 $\rightarrow$ 4 and 4 $\rightarrow$ 3.
5- Plot these transitions on an energy diagram.

Exercise n°9 **

1-Consider an excited hydrogen atom that returns to its ground state by emitting a line with a wavelength of 1216 A°. (R_H = 1.1 × 10^7 m^{-1}).

What are the quantum numbers n_1 and n_2 that characterise this transition?

2- One of the emission lines of the hydrogen atom has a wavelength λ = 4850 A°. Give the transitions that correspond to this series.

3- The wavelength of the first line of a spectral series of the hydrogen atom is λ = 18700 A°.

a- Give the name of this series.

b- Calculate the energy of the photon corresponding to the second line of this series.

c- Calculate the energy of the photon corresponding to the last line of this series. What is this type of transition called?

Exercise n°10 **

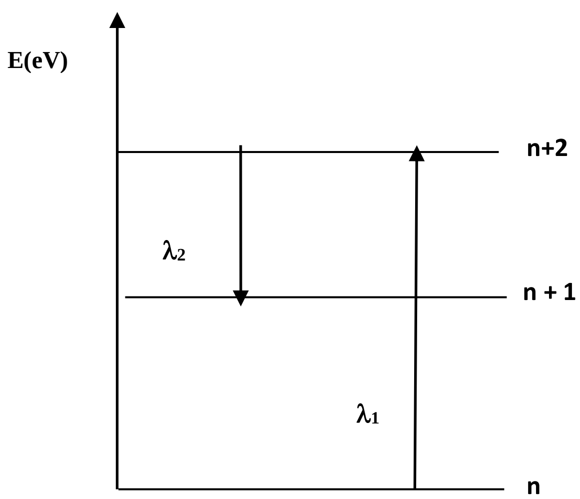
a) Let the hydrogen atom initially in the ground state, it absorbs a photon of wavelength 900A°. Show that the atom is ionized.

b) An excited hydrogen atom returns to its ground state by emitting a line with a wavelength of 1216 A°. Determine the levels n_1 et n_2 that characterize this transition, and indicate in which region of the electromagnetic spectrum this line is located. (R_H =1.1 10^7 m^{-1})

Exercise n° 11***

Let the transitions of the electron of a hydrogen atom be represented on the energy diagram. Knowing that (n+1) corresponds to the fundamental state of the series that is in the infrared (IR): **(1)** calculate the states n, n+1, n+2.

(2) Find the wavelengths λ_1 et λ_2 in (A°**).**



Exercise n° 12**

Represent the following transitions on an energy diagram:

1) 3^{rd} absorption line of Balmer.
2) 2^{nd} emission line of Lyman.
3) 2^{nd} absorption line of Paschen.
4)1^{st} emission line of Brackett.

Exercise n°13*

The hemoglobin-CO complex absorbs radiation of l 953 cm^{-1}. Calculate the wavelength of the radiation (in nm), its frequency (in Hz), and its energy (en $kJ \cdot mol^{-1}$).

Exercise n°14*

The barium atom emits light with a frequency of 5.41×10^{14} Hz. Is this light part of the visible spectrum?

Exercise n°15**

The energy required to remove the 3s electron from sodium is 5.14 eV. Calculate the wavelength of radiation that ionises sodium.

Tutorial 2 Solutions

Exercise n°1

λ = 5900 A° *λ = 59 10^{-8} m* / *1 A°= 10^{-1} m*

a) The wave number**:* $\bar{\nu} = \frac{1}{\lambda} = \frac{1}{59\ 10^{-8}}$, therefore ***$\bar{\nu}$ = 1694915 m^{-1}

b) The frequency** : $\nu = \frac{c}{\lambda} = \frac{3\ 10^{8}}{59\ 10^{-8}}$, therefore* ***$\nu$ = 5.08 10^{14} s^{-1} (Hz)

c) the energy of the emitted photon:

ΔE = h ν = 6.62 10^{-34} (J.s) . 5.08 10^{14}, Therefore : ***ΔE = 3.36 10^{-19} joules***

Exercise n°2

a) Ground state : $n_1 = 1$ λ_1= 972,8 A°

$\bar{\nu} = \frac{1}{\lambda_1} = R_h\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ avec **(n_2 > n_1)**

Absorption de n_1= 1 $\longrightarrow$ n_2, On a : $\frac{1}{\lambda_1} = \frac{1}{972.8\ 10^{-10}}$ 1.1 10^7 $\left(\frac{1}{1^2} - \frac{1}{n_2^2}\right)$

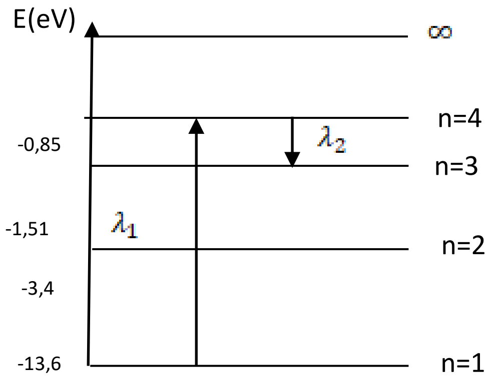
We obtain **n_2 = 4** therefore an absorption of n_1= 1 $\longrightarrow$ n_2 = 4

For λ_2= 18790 A° we have an emission of n_2 = 4 $\longrightarrow$ n'_1

replaces in Balmer's relation: $\frac{1}{\lambda_2} = R_h\left(\frac{1}{n'^2_1} - \frac{1}{4^2}\right)$ avec $n'_2 > n'_1$

Therefore de ***n'_1 = 3***, we have an emission of n_2 = 4 $\longrightarrow$ n'_1 = 3

Representation



c) ***Ionisation energy***: $E_i = E_\infty - E_n$ for the level n=1 we have :

Ei = - E_1 = - (- 13.,6)

Therefore ***Ei = 13.6 eV*** **(Ei > 0 because it is an absorption)**

Exercise n°3

1) λ corresponds to the shortest wavelength, therefore it is the limiting line that corresponds to the transition : $n_1 \longrightarrow \infty$

We have the hydrogenate of beryllium. ${}_4Be^{3+}$, we apply Balmer's relation:

$$\frac{1}{\lambda} = R_h\, Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \quad \text{with} \quad \mathbf{n_2 > n_1}$$

$$\frac{1}{57.3\ 10^{-10}} = 1{,}1\ 10^7 \left(\frac{1}{n_1^2} - 0\right) \Longrightarrow \boldsymbol{n_1 = 1}$$

(The transition: $n_1 = 1 \longrightarrow n_2 = \infty$), it's an ionisation.

The energy that corresponds to this transition: $Ei = E_\infty - E_1 = -(Z^2 E_1) \Longrightarrow$ ***Ei = 217.6 eV***

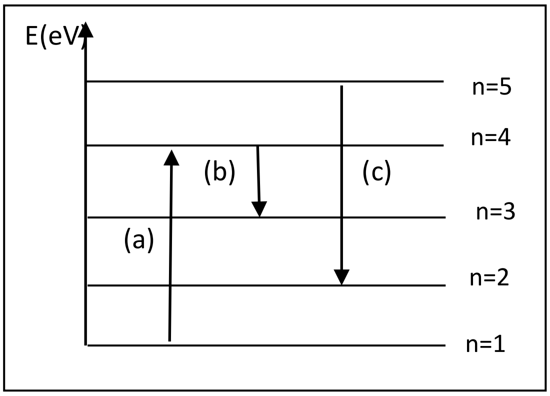
2) The wavelength corresponding to the same transition for the hydrogen atom:

$$\frac{1}{\lambda'} = R_h \left(\frac{1}{n_1^2} - 0\right) \Longrightarrow \frac{1}{\lambda'} = R_h \qquad \lambda' = \frac{1}{Rh} = 9.09\ 10^{-8}\ \text{m} = 909\ \text{A°}$$

λ' = 909 A°

This is ionisation energy. Therefore : $Ei = E_\infty - E_1$, ***Ei = + 13.6 eV***

3)



(a) 3rd absorption line of Lyman.

(b) 1st emission line of Paschen.

(c) 3rd emission line of Balmer.

Exercise n°4

1) *The energies of the electron at different levels:*

$\Delta E = E_{final} - E_{initial}$

Fundamental state $\Longrightarrow$ $E_i = E_1$ = -13.6 eV, Therefore : $E_{initiale} = E_1$ = -13.6 eV

The final energy will be: $\mathbf{E_f = \Delta E + E_i}$

$\Delta E_1 = 10.20$ eV $\Longrightarrow$ $\boldsymbol{E_{f1}}$ = 10.20 – 13.6 = ***- 3.4 eV***

$\Delta E_2 = 12.08$ eV $\Longrightarrow$ $\boldsymbol{E_{f2}}$ = 12.08 – 13.6 = ***- 1.52 eV***

$\Delta E_3 = 12.74$ $\Longrightarrow$ $\boldsymbol{E_{f3}}$ = 12.74 – 13.6 = ***- 0.86 eV***

The levels (orbits) for each energy :

The energy of an electron in an orbit is: $E_n = E_1 / n^2$ (E_1 = - 13.6 eV)

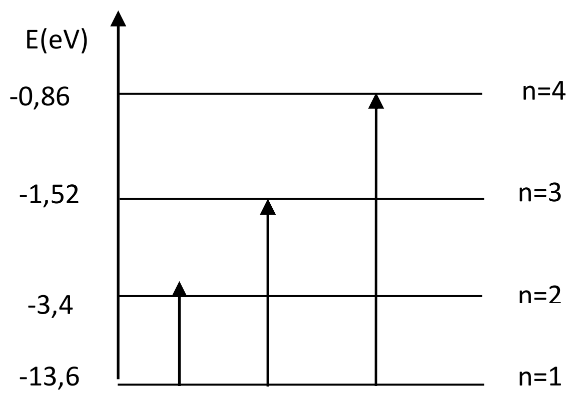
The orbit $n = \sqrt{\frac{E1}{En}}$ The orbits are :

$n_1 = \sqrt{\frac{13.6}{3.4}}$ $\Rightarrow$ $\mathbf{n_1 = 2}$

$n_2 = \sqrt{\frac{13.6}{1.5}}$ $\Rightarrow$ $\boldsymbol{n_2 = 3}$ ***1 eV = 1.6 10^{-19} Joules***

$n_3 = \sqrt{\frac{13.6}{0.86}}$ $\Rightarrow$ $\boldsymbol{n_3 = 4}$

2) The energy diagram



This is the Lyman absorption series.

3) Wavelength of each transition (Absorption)

We have $\Delta E = h\nu = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{\Delta E}$ or :

$\bar{\nu} = \frac{1}{\lambda} = Rh\ (\frac{1}{n_1^2} - \frac{1}{n_2^2})$ **(n_2 > n_1)**

$\Delta E_1 \Rightarrow \lambda_1 = \frac{hc}{\Delta E_1} = \frac{6.62\ 10^{-34} .\ 3\ 10^8}{10.20 \times 1.6\ 10^{-19}}$

λ_1 = 1.21 10^{-17} m = 1210 . 10^{-10} m = 1210 A° **λ_1 = *1210 A°***

$\bar{\nu}_2 = \frac{1}{\lambda_2}$ = Rh (1.1 10^{-7}) $(\frac{1}{1^2} - \frac{1}{3^2})$

λ_2 = 10227272.73 m = 1.022 10^{-7} m = 1022 A° ***λ_2 = 1022 A°***

$\bar{\nu}_3 = \frac{1}{\lambda_3}$ = 1.1 10^{-7} $(\frac{1}{1^2} - \frac{1}{4^2}) \Rightarrow$ λ_3= 9696969.97 m

λ_3= 9696969.97 m = 9.969 10^{-6} m = 969.6 A° **λ_3 = *969.6 A°***

Exercise n°5 :

The 3rd ionization energy of lithium : $_3Li^{2+}$ is the hydrogenoid of lithium

$Li^{2+} \longrightarrow Li^{3+}$ + 1 e- $3^{ème}$ ionisation

$E_i = \cancel{E_\infty} - E_n = -E_n = -\frac{Z^2 E'_1}{n^2}$

0

$E_i = -\frac{3^2\,(-13.6)}{1}$ = 122.4 eV ***Ei = 122.4 eV***

We have 1 eV = 1.6 10^{-19} joules

Therefore : $\boldsymbol{E_i}$ ***= 195.84 10^{-19} joules***

The wavelength and frequency of the line that corresponds to the transition *n= 4 → n= 1.*

$\frac{1}{\lambda} = Z^2\ Rh\ (\frac{1}{n_1^2} - \frac{1}{n_2^2})$ with **n2 > n1**

$\frac{1}{\lambda} = 3^2\ 1.1\ 10^{-7} (\frac{1}{1^2} - \frac{1}{4^2}) \Rightarrow$

λ = 1.086 10^{-8} m = 108.06 10^{-10} m = 108.06 A° **λ = *108.06 A°***

The frequency : $\nu = \dfrac{c}{\lambda} = \dfrac{3\ 10^8}{1.0806\ 10^{-8}} = 2.77\ 10^{16}\ s^{-1}$ (Hz)

$\boldsymbol{\nu = 2.77\ 10^{16}\ s^{-1}}$ ***(Hz)***

Exercise n°6

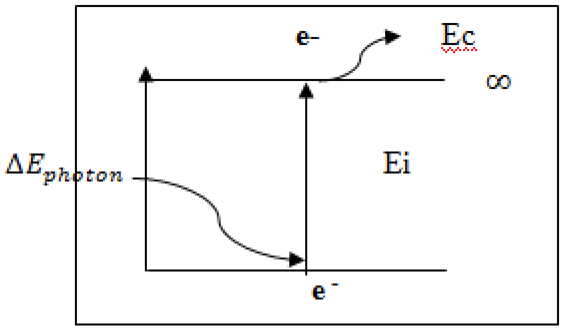
λ = 1027 A° belongs to the Lyman series $\Rightarrow$ $\boldsymbol{n_1 = 1}$

1) $\dfrac{1}{\lambda} = R_H \left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right)$ $(n_2 > n_1)$ Emission of $n_2 = 3 \longrightarrow n_1$

$n_2 = 3$ we are looking for n1 λ = 1027 A°

$$\frac{1}{1027\ 10^{-10}} = 1.1\ 10^{-7} \left(\frac{1}{n_1^2} - \frac{1}{9}\right) \Longrightarrow \boldsymbol{n_1 = 1}$$

2) An electron is released, therefore this is ionisation.



On a ; $E_{(photon)} = E_{(ionisation)} + E_{(kinetic)}$

$E_{(ionisation)} = \cancel{E_\infty} - E_1$ X : hydrogenoid

0

$E_i = -E_1 = -Z^2 \dfrac{E_1}{1^2} = -Z^2 \dfrac{(-13.6)}{1^2}$ Therefore $E_i = Z^2\ 13.6$

Furthermore, we have: $E_{(ionisation)} = E_{(photon)} - E_{(cinétique)}$ ………… relation (1)

$E_{(photon)} = h\nu = \dfrac{hc}{\lambda} = \dfrac{6.62\ 10^{-34}\ .\ 3\ 10^8}{64\ 10^{-10}} = 3.103\ 10^{-17}$ joules and we have :

1 eV = $1.6\ 10^{-19}$ joules Therefore : $\boldsymbol{E_{(photon)} = 193.94}$ ***eV***

We replace in reation (1): $E_{(ionisation)} = 193.94 - 71 = 122.94$ eV = $13.6\ Z^2$,

$Z^2 = 9.039 \Longrightarrow$ ***Z = 3*** (lithium)

Exercise n°7

The energy carried by radiation is :

E or $\Delta E = h\,\nu = \frac{hc}{\lambda} = \frac{6.62\ 10^{-34}\ x\ 3\ 10^{8}}{5000\ \ 10^{-10}}$

E = 3.972 10^{-19} joules

In electron -Volt : 1 eV $\longrightarrow$ 1.6 10^{-19} joules

x eV $\longrightarrow$ E (joules)

The energy of radiation in (eV) : x = ***E (eV) = 2.4825 eV***

The wave number: $\bar{\nu} = \frac{1}{\lambda}$ Therefore **$\bar{\nu}$ = 2 10 $A°^{-1}$ = 2 10^{6} m**

In calories : 1 cal $\longrightarrow$ 4.18 joules

y —— 3.972 10^{-19} joules

The energy of radiation in calories = ***E(cal) = 9.502 10^{-20} cal = 9.502 10^{-23} Kcal***

Exercise n°8

For the orbit n = 3

1) ***The radius :*** $\mathbf{r_n = r_0\, n^2}$ = 0.53 . 9 = 4.77 A° ***r_3 = 4.77 A°***

2) ***Orbital energy :*** **En =** $\frac{E_1}{n^2} = -\frac{13.6}{9}$ = - 1.51 eV ***E_3 = - 1.51 eV***

3) ***Ionisation energy*** : $Ei = E_\infty - E_n$

$\underbrace{\cancel{E_\infty}}_{0} - E_3 = -E_3 = +1.51$ eV Therefore ***$E_{ionisation}$ = 1.51 eV***

4) We are looking for the wavelength (A°) that corresponds to the transitions . 3 $\longrightarrow$ 4 and 4 $\longrightarrow$ 3

$\lambda_{3-4} = \lambda_{4-3}$

Either $\Delta E_{3\to4} = h\,\nu = \frac{hc}{\lambda}$ therefore :

$\lambda_{3-4} = \frac{hc}{\Delta E}$

Or we apply Balmer's relation

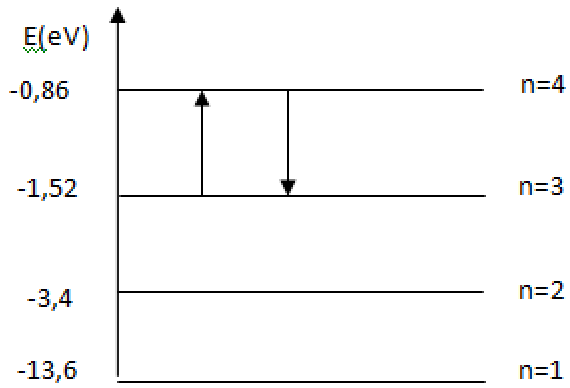
$\frac{1}{\lambda}$ = Rh $(\frac{1}{n_1^2} - \frac{1}{n_2^2})$ with **$n_2 > n_1$**

$\frac{1}{\lambda_{3\to4}}$ = $1.1\ 10^7\ (\frac{1}{9} - \frac{1}{16})$ therefore **$\lambda_{3\to4}$ =1.8701 10^{-6} m**

$\lambda_{3\to4}$ =18701 10^{-10} m = 18701 A°

The ground state **n = 3** corresponds **to Paschen's series**, therefore this line actually belongs to this series [18750 $\geq \lambda \geq$ 10940] and is found in IR.

5) The energy diagram



Exercise n°9

1) The electron returns to its ground state, therefore ***n1 = 1***, we are looking for ***n2***.

λ = 1216 A° ⇒ Lyman's serie and therefore ***n1 = 1***

We apply Balmer's relation:

$\bar{\nu} = \frac{1}{\lambda}$ = Rh $(\frac{1}{n_1^2} - \frac{1}{n_2^2})$ with ***$n_2 > n_1$***

$\frac{1}{\lambda}$ = 1.1 107 $(1 - \frac{1}{n_2^2})$ *therefore* $\frac{1}{\lambda\ Rh} - \frac{1}{n_2^2} = -\frac{1}{n_2^2}$

$\frac{1}{n_2^2} = 1 - \frac{1}{\lambda\ Rh}$

$\frac{1}{n_2^2} = 1 - \frac{1}{1216\ 10^{-10}.1.1\ 10^7}$ therefore ***n_2 = 1.99*** ⇒ ***n_2 = 2***

2) λ **= 4850 A° we are looking for n_1 and n_2**

$\bar{\nu} = \frac{1}{\lambda} = Rh\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ and ***n_2 > n_1***

λ = 4850 A° it belongs to the Balmer series . [6563 ≥ λ ≥3636] therefore ***n_1 = 2***

we are looking for n_2 :

$$\frac{1}{\lambda\, Rh} = \frac{1}{n_1^2} - \frac{1}{n_2^2} \Rightarrow \frac{1}{n_2^2} = \frac{1}{n_1^2} - \frac{1}{\lambda\, Rh}$$

$$\frac{1}{n_2^2} = \frac{1}{4} - \frac{1}{4850\ 10^{-10}\ .\ \ 1.1\ 10^{7}}$$ Therefore

n_2^2 = 15.98 ⇒ n_2 = 3.99 ⇒ ***n_2 = 4***

The emission of $n_2 = 4 \longrightarrow n_1 = 2$

3) a) λ = 18700 A° this line belongs **to Paschen's series**. therefore ***n_1 = 3*** (is located in IR)

b) The energy of the 2nd ray in this series corresponds to the transition. $n_1 = 3 \longrightarrow n_2 = 5$

$$\Delta E_{3\to5} = E_5 - E_3 = \boldsymbol{0.966\ eV}$$

c) The energy corresponding to the last line in this series is the ionisation energy. We have the transition of the electron de $n_1 = 3 \longrightarrow n_2 = \infty$

Ei = $\underbrace{\cancel{E_\infty}}_{0}$ - E_3 = - E_1 / n^2 = - (-13.6) / 3^2 therefore ***Ei = + 1.51 eV***

Exercise n°10

a) Fundamental state ⇒ ***n=1*** therefore the minimum energy required to ionise the atom of hydrogen will be : Ei = $\underbrace{\cancel{E_\infty}}_{0} - E_1$ therefore Ei = - (-13,6) eV ***Ei = + 13.6 eV***

minimum energy

The energy absorbed by the hydrogen atom (λ = 900 A°) :

$$\Delta E = h\,\nu = \frac{hc}{\lambda} = \frac{6.62\ 10^{-34}.\ 3\ 10^{8}}{900\ -10^{-10}} = 2.2\ 10^{-18}\ \text{joules}$$ ***$\Delta E_{Absorbed}$ = 2.2 10^{-18} joules***

We have : 1 eV = 1.6 10^{-19} Joules, therefore

1 eV ———— 1.6 10^{-19}J

E_{Abs}(eV) ———— E_{Abs} (2.2 10^{-18} joules) ***E_{Abs} = 13.75 eV***

E_{Abs} > Ei therefore the hydrogen atom is ionised..

b) the atom returns to its ground state, therefore n1 = 1, and this is an emission..

Or : ***λ= 1216 A°*** belongs to Lyman's series therefore n_1 = 1. ***Let's look for n_2*** :

$$\bar{\nu} = \frac{1}{\lambda} = Rh\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \qquad (n_2 > n_1)$$

$$\frac{1}{\lambda\, Rh} = 1 - \frac{1}{n_2^2} = \frac{1}{1216\ 10^{-10}\ .1.1\ 10^7} \quad \Rightarrow \quad \boldsymbol{n2 = 1.99 = 2}$$

Emission of ***n2 = 2*** $\longrightarrow$ ***n1 = 1***. It is Lyman's series, therefore the line is found in UV.

Exercise n°11

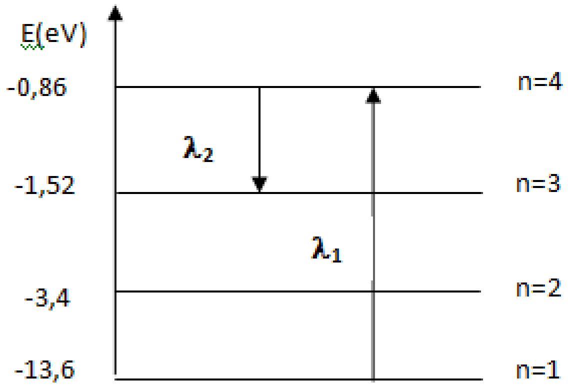
1) The series found in IR is the Paschen series $\Rightarrow$ n + 1 =3 therefore n = 2 and n + 2 = 4

2) $\lambda_1 = \frac{1}{\lambda_1} = Rh\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ λ_1 corresponds to the transition : n_1 =2 $\longrightarrow$ n_2 = 4

$\frac{1}{\lambda_1} = 1.1\ 10^7\left(\frac{1}{4} - \frac{1}{16}\right)$ therefore ***λ_1 = 4.848 10^{-7} m = 4848 A°***

$\frac{1}{\lambda_2} = Rh\left(\frac{1}{3^2} - \frac{1}{4^2}\right)$ λ_2 corresponds to the transition : n_1 =3 $\longrightarrow$ n_2 = 4

λ_2 = 1.8701 10^{-6} m = 18701 A°



Exercise n°12

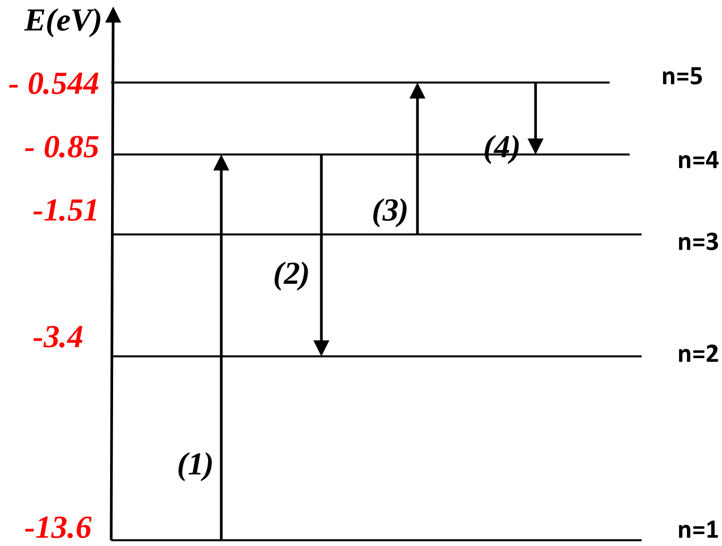
Transitions are represented on an energy diagram.:

1) 3rd abs line of Lyman $n = 1 \longrightarrow n = 4$

2) 2^{nd} emis line of Balmer $n = 4 \longrightarrow n = 2$

3) 2^{nd} abs line of Paschen $n = 3 \longrightarrow n = 5$

4) 1^{st} emis line of Brackett $n = 5 \longrightarrow n = 4$



Exercise n°13

The wavelength for radiation is given in cm^{-1} therefore $\frac{1}{wavelength}$

Wavelength : $\lambda = \frac{1}{1953\ cm^{-1}}$ = $5.12033 \cdot 10^{-4}$ cm = ***5120.33 nm***

The frequency and energy of radiation:

$$V = \frac{c}{\lambda} = \frac{3.00 \cdot 10^{8}\ m.s^{-1}}{5.12 \cdot 10^{-6} m} = 5.86 \cdot 10^{13}\ s^{-1} = \mathbf{5.86\ \ 10^{13}\ Hz}$$

$E_{chemical} = h\ \nu\ N_A = 6.625 \cdot 10^{-34}$ J. s x $5.86 \cdot 10^{13}\ s^{-1}$ x $6.022 \cdot 10^{23}\ mol^{-1}$

$$\boldsymbol{E_{chemical} = 23379\ J.mol^{-1} = 23.38\ kJ.mol^{-1}}$$

Exercise n°14

The absorption wavelength of barium :

$\nu = \frac{c}{\lambda} \longrightarrow \lambda = \frac{c}{\nu} = \frac{3.00\,.10^{8}\ m.s^{-1}}{5.41\,.10^{14} s^{-1}}$ = 5.55 . 10^{-7} m therefore λ ***= 555 nm***

This light is part of the visible spectrum because its wavelength is between 400 nm and 750 nm.

Exercise n°15

The energy E required to remove an electron from an atom is related to the frequency ν of the radiation by the relationship: $E = h\,\nu$

Where h is Planck's constant ($h = 6.6261\ 10^{-34}$ J s).

Frequency itself is related to wavelength λ by the relationship :

$$\nu = \frac{c}{\lambda}$$

Where **C** is the speed of light in a vacuum ($c = 3 \times 10^{8}$ m/s). Combining these two relationships, we get:

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

To maintain consistency in units, E must be expressed in joules. .:

$E = 5.14 \times 1.6\ 10^{-19} = 8.224\ 10^{-19}$ J therefore ***E = 8.224 10^{-19} Joules***

And the wavelength will be:

$$\lambda = \frac{hc}{E} = \frac{6.63\,.10^{-34}\ Js\ .\ 3\ .\ 10^{8} m\,s^{-1}}{8.224\ .\ 10^{-19} J} = 2.42\ 10^{-7}\ \text{m} = 242\ \text{nm}$$

λ ***= 242 nm***

Tutorial 3
(Quantum description of the atom
and periodic classification of the elements)

Exercise n°1*

Determine the wavelength associated with:

a) A ball with a mass of 2 g and a velocity of 300 m/s..

b) An electron with a kinetic energy of 54 eV.

Exercise n°2**

1) Among the quantum number combinations, tick the boxes that are possible and give the name of the corresponding orbital (1s, 2p, ...).

	n	L	m	S	Name of the orbital
	2	2	0	½	
	1	0	0	½	
	6	1	1	-1/2	
	5	2	1	-1/2	
	3	1	1	0	
	4	3	2	-1/2	

2) How many electrons can be placed in the L shell defined by n = 2? Justify your answer.

3) What is the number of valence electrons in vanadium V (Z = 23) and gallium Ga (Z = 31)? Give the four quantum numbers of the valence electrons in gallium.

Exercise n°3**

Among the following atomic orbitals, indicate which ones are incorrect. Name the AOs..

Ψ(1 ,0 ,0) Ψ(2 ,1 ,0) Ψ(4 ,3 ,-2) Ψ(2 ,0 ,1) Ψ(5 ,2 ,0) Ψ(1 ,1 ,0) Ψ(2,2 ,2)

To which subshell does the AO Ψ(2, 1, 0) belong? Which other AOs belong to the same subshell ? Represent them on an Oxyz coordinate system.

Exercise n°4**

Let us consider the following atoms: $_{7}N$; $_{15}P$; $_{20}Ca$; $_{22}Ti$; $_{34}Se$; $_{38}Sr$ $_{78}Pt$

a) Give the electron configuration of the atoms and indicate the valence electrons.

b) Locate the elements in the periodic table and give the ions of: $_{20}Ca^{2+}$; $_{34}Se^{2-}$

c) Place the valence electrons of $_{78}Pt$ in quantum boxes and indicate the external and internal valence subshell and the valence shell.

d) Give the atom that belongs to the period of $_{3}Li$ and the arsenic family $_{33}As$.

e) Classify the elements in ascending order of electronegativity.: $_{22}Ti$; $_{34}Se$; $_{38}Sr$; $_{20}Ca$.

Exercise n°5 **

Let us consider the following atoms:

$_{51}Sb$; $_{28}Ni$; $_{12}Mg$; $_{33}As$; $_{20}Ca$

a) Give the electronic configuration of the atoms.

b) Locate them in the periodic table

c) Place the valence electrons of $_{51}Sb$ in quantum boxes and indicate the external and internal valence s/c and the valence shell.

d) Give the ions of : $_{20}Ca$; $_{12}Mg$

e) Place the valence electrons of ($_{33}As$) in quantum boxes and give the quantum numbers of the unpaired electrons.

f) Which element has the largest atomic radius and which has the smallest (ra)?

g) Among the elements in group IIA (if any), which is the most electronegative, and among those in period 4 (if any), which is the least electronegative.

h) Identify the paramagnetic and diamagnetic elements

Exercise n°6 *

1) Name the following atomic orbitals:

Ψ (3,0,0), Ψ(3,-1,0), Ψ(3,1,-1), Ψ(4,3,-1),), Ψ(2,2,2), Ψ(4,2,-2).

2) Given the following AOs, name them using the function Ψ(x, y, z) :

$3p_{-1}$, $3d_{-2}$, $3f_{-2}$, $2s_0$, $3p_0$, $3d_{-2}$.

Exercise n°7 ***

1) Provide the electronic configuration of the following elements : $_{37}$Rb, $_{12}$Mg, $_{13}$Al, $_{31}$Ga, $_{38}$Sr, $_{33}$As, $_{8}$O, $_{52}$Te et $_{84}$Po.

2) Locate these elements in the periodic table of elements.

3) What is the most stable ion that can be obtained from the following elements : $_{37}$Rb, $_{12}$Mg, $_{13}$Al, $_{38}$Sr, $_{8}$O, $_{52}$Te et $_{84}$Po.

4) Determine the core electrons, valence electrons, valence shell, external and internal valence subshells for element $_{84}$Po, and place the valence electrons in quantum boxes.

Exercise n°8**

An element has fewer than 20 electrons and two unpaired electrons. What are its possible configurations? What is this element, given that it belongs to the period of $_{11}$Na and the group of $_{34}$Se.

Exercise n°9 ***

1) What is the atomic number of the atom whose X+ cation has the same electronic structure as argon ($_{18}$Ar) and the atomic number of the atom whose X- anion has the same electronic structure as argon?

2) Name the element that belongs to column VIa and period 4.

3) Give the element that belongs to the period of lithium (3Li) and the family of arsenic ($_{33}$As).

Exercise n°10***

1)

A) Locate elements in the periodic table***:*** $_{56}Ba$; $_{27}Co$; $_{20}Ca$; $_{34}Se$.

B) Give the stable ions of $_{20}Ca$; $_{34}Se$**.**

C) Classify the elements in ascending order of electronegativity..

D) Indicate the element with the largest atomic radius.**.**

E) 1) X belongs to the VA family and the 3rd period. Give its atomic number..

2) X belongs to the 5th period and the boron family ($_{5}B$). Give ZX..

Exercise n°11**

Give the atomic number of X and Y, knowing that :

a) X^{3+} has the structure of ($_{10}Ne$).

b) Y belongs to the same period as X, and Y is missing two electrons to have the structure of a noble gas.

Exercise n°12*

Explain why the V^{5+} ion is more stable than the V^{2+} ion.

Exercise n°13**

In the copper atom in its ground state, how many electrons are characterised by the magnetic quantum number m = +1?

Exercise n°14*

Determine the period and column of the elements whose atomic numbers are 8 and 19, respectively.

Tutorial 3 Solutions

Exercise n°1

De Broglie wave : $\lambda = \dfrac{h}{m\,v}$

a) λ of the ball : mass = 2g velocity = 300 m/s

$\lambda = \dfrac{6.62\ 10^{-34}}{2\ 10^{-3}\ .300}$ $\Rightarrow$ ***λ = 1.1 10^{-33} m = 1.1 10^{-23} A°***

λ of the ball is infinitely small, therefore the Broglie wavelength is insignificant on a macroscopic scale.

b) λ of an electron with kinetic energy : Ec = 54eV

Ec = $\dfrac{1}{2}$ m v^2 $\Rightarrow$ v = $\sqrt{\dfrac{2\,Ec}{m\,e-}}$ therefore $\lambda = \dfrac{h}{n\,v} = \dfrac{6.62\ 10^{-34}}{9.1\ 10^{-31}\sqrt{\dfrac{2\,Ec}{m\,e-}}}$

$\lambda = \dfrac{6.62\ 10^{-34}}{9.1\ 10^{-31}\sqrt{\dfrac{2\ .54\ .1.6\ 10^{-19}}{9.1\ 10^{-31}}}}$ ***λ = 1.67 10^{-10} m = 1.67 A°***

De Broglie's wavelength is significant at the microscopic scale..

Exercise n°2 1)

	n	ℓ	m	s	Name of the orbital	
No	2	2	0	1/2	does not exist because (ℓ) does not satisfy the condition	
✓	1	0	0	1/2	$1s_0$	ψ (1,0,0)
✓	6	1	1	-1/2	$6p_{+1}$	ψ(6,1,1)
✓	5	2	1	-1/2	$5d_{+1}$	ψ(5,2,1)
No	3	1	1	0	does not exist because (ℓ) does not satisfy the condition	
✓	4	3	2	-1/2	$4f_{+2}$	ψ(4,3,2)

Conditions : For an atomic orbital to exist, it must:

The principal quantum number (**n**) verifies: ***$n \in N^*$***

The secondary quantum number (ℓ) verifies : $0 \leq \ell \leq n\text{-}1$

The magnetic quantum number **(m)** verifies : $-\ell \leq m \leq +\ell$

The spin checks : S = $\pm$ 1/2

2) The maximum number of electrons in the layer L (n = 2) :

n = 2 $\quad 0 \leq \ell \leq n\text{-}1 \quad \Rightarrow \quad 0 \leq \ell \leq 1 \quad \left.\begin{array}{l} \ell = 0 \textit{ therefore subshell } 2s \\ \ell = 1 \textit{ therefore subshell } 2p \end{array}\right\}$

Therefore 2 electrons in the 2s subshell and 6 electrons in the 2p subshell.

The maximum number of electrons in the L shell is **8 electrons**.

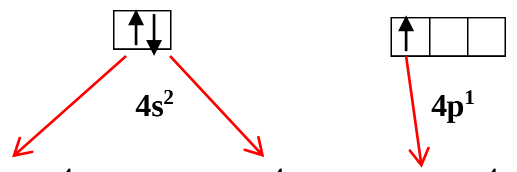
***3)* The valence electrons of Vanadium :**

$_{23}V$: $[_{18}Ar]$ $4s^2 4d^3$ number of e- of valence : **5 e-**

$_{31}Ga$: $[_{18}Ar]$ $4s^2\ 3d^{10}\ 4p^1$

The valence electrons of Gallium: 3 e-

The quantum numbers of Gallium valence electrons $_{31}Ga$: $[_{11}Ar]$ $4s^2\ 3d^{10}\ 4p^1$



4s² **4p¹**

n = 4	n = 4	n = 4
ℓ = 0	ℓ = 0	ℓ = 1
m = 0	m = 0	m = -1, 0, +1
s = + ½	s = - 1/2	s = + ½

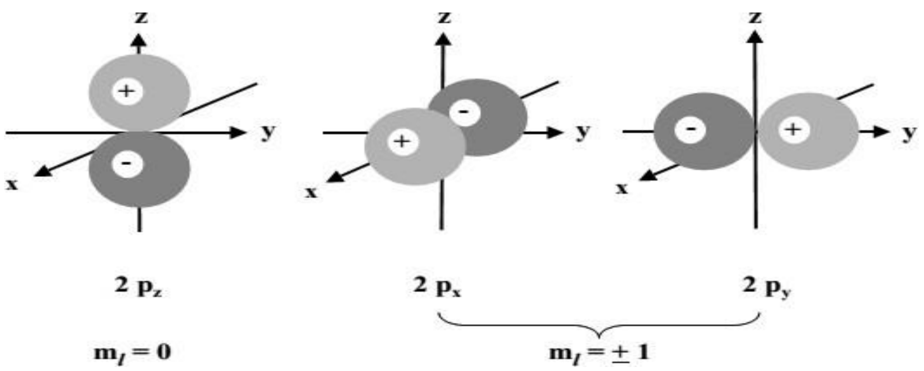
Exercise n°3 :

a) Conditions: n ∈ IN $\quad$ **$0 \leq \ell \leq n\text{-}1$** $\quad$ **$-\ell \leq n \leq +\ell$**

	Names of atomic orbitals
$\psi(1,0,0)$	$1s_0$
$\psi(2,1,0)$	$2p_0$
$\psi(4,3,-2)$	$4f_{-2}$
$\psi(2,0,1)$	*False because ℓ does not check the condition*
$\psi(5,2,0)$	$5d_0$
$\psi(1,1,0)$	*False because ℓ does not check the condition*
$\psi(2,2,2)$	*Fausse because ℓ does not check the condition*

b) The atomic orbital (AO)* ψ *(2,1,0)ou* (2p₀),** therefore the AO belongs to layer L (n = 2) and to the subshell 2p (ℓ = 1) therefore there is 3(0A) in the subshell 2p. These are: ***$2p_{-1}$* , *$2p_0$* , *$2p_{+1}$

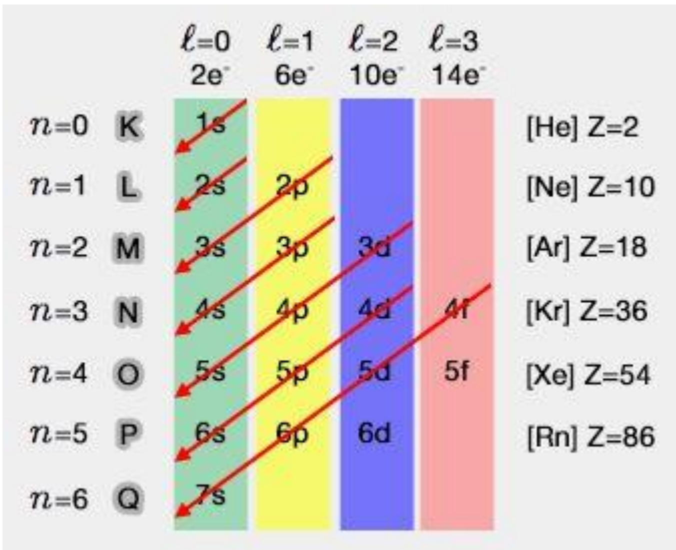
Representation of the three orbitals of subshell 2p :



Exercise n°4

a) the electronic procession of the elements:

We apply Klechkowski's rule (or energy order)



On this energy diagram, we observe that the energetic filling order is as follows : 1s 2s 2p 3s 3p 4s 3d 4p 5s 4d 5p 6s 4f 5d 6p …..

$_7N$: $1s^2/2\ s^2\ 2p^3$

($_2He$) $2s^2\ 2p^3$ ***5 valence electrons***

$_{15}P$: $1s^2 2s^2 2p^6 / 3s^2 3p^3$

$_{15}P$: $(_{10}Ne)\ 3s^2\ 3p^3$ ***5 valence electrons***

$_{20}Ca$: $1s^2 2s^2 2p^6 3s^2 3p^3 3s^2 3p^3 / 4s^2$

$_{20}Ca$: $(_{18}Ar)\ 4s^2$ ***2 valence electrons***

$_{22}Ti$: $1s^2 2s^2 2p^6 3s^2 3p^6 / 4s^2 3d^2$

$_{22}Ti$: $(_{18}Ar)\ 4s^2 3d^2$ ***4 valence electrons***

$_{34}Se$: $1s^2 2s^2 2p^6 3s^2$ 3p6/ $4s^2 3d^{10} 4p^4$

$_{34}Se$: $(_{18}Ar)\ 4s^2 3d^{10} 4p^4$ ***6 valence electrons***

$_{38}Sr$: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 / 5s^2$

$_{38}Sr$: $(_{36}Kr)\ 5s^2$ ***2 valence electrons***

$_{78}Pt$: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6\ 5s^2 4d^{10} 5p^6 / 6s^2 4f^{14} 5d^8$

$_{78}Pt$: $(_{54}Xe)\ 6s^2 4f^{14} 5d^8$ ***10 valence electrons***

b) Situation des éléments dans le tableau périodique :

Element	***Procession***	***Number of valence electrons***	***Family***	***Period***
$_7N$	$(_2He)\ 2s^2 2p^3$	5	VA	n = 2
$_{15}P$	$(_{10}Ne)\ 3s^2 3p^3$	5	VA	n = 3
$_{20}Ca$	$(_{18}Ar)\ 4s^2$	2	IIA	n = 4
$_{22}Ti$	$(_{18}Ar)\ 4s^2 3d^2$	4	IVB	n = 4
$_{34}Se$	$(_{18}Ar)\ 4s^2 3d^{10} 4p^4$	6	VIA	n = 4
$_{38}Sr$	$(_{36}Kr)\ 5s^2$	2	IIA	n = 5
$_{78}Pt$	$(_{54}Xe)\ 6s^2 5d^8$	10	VIIIA *(Triades Bloc d)*	n = 6

The stable ions of Ca et Se :

We have : Ca $\longrightarrow$ Ca^{2+} + 2 e^- et Se + 2 e^- $\longrightarrow$ Se^{-2}

${}_{20}Ca$: $({}_{18}Ar)\ 4s^2$ $\Rightarrow$ ${}_{20}Ca^{2+}$: $[{}_{18}Ar]\ 4s^0$ **${}_{20}Ca^{2+}$: $[{}_{18}Ar]$**

${}_{34}Se$: $({}_{18}Ar)\ 4s^2 3d^{10} 4p^4$ ${}^{4}{}_{34}Se^{2-}$: $[{}_{18}Ar]\ 4s^2 3d^{10} 4p^6$ **Se^{2-}: $[{}_{36}Kr]$**

c) ${}_{78}Pt$: $[{}_{54}Xe]\ 6s^2 4f^{14} 5d^8$ Il a **10 *valence electrons***

[↑↓] [↑↓|↑↓|↑↓|↑|↑]

$6s^2$ ***$5d^8$***

${}_{78}$Pt: $[{}_{54}Xe]\ 6s^2 4f^{14} 5d^8$

- valence shell **n=6**
- e- of core = **68**
- e- of valence = **10**
- Subshell of external valences : 6s
- Subshell of internal valences : 4f, 5d 5d

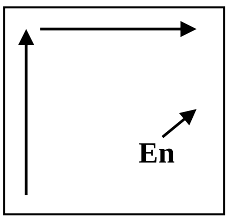
d) X $\in$ period of ${}_{3}Li$: $({}_{2}He)\ 2s^1$ $\Rightarrow$ **n = 2**

X $\in$ family of ${}_{33}$ As : $({}_{18}Ar)\ 4s^2 3d^{10} 4p^3$ Family VA

X ends therefore : $2s^2\ 2p^3$

X: $1s^2 2s^2 2p^3$ therefore **Z = 7 (nitrogen)**

e) Electronegativity (En) varies in the periodic table as follows::



Ranking of elements in ascending order of electronegativity: ${}_{22}$ Ti ; ${}_{34}$ Se ; ${}_{38}$ Sr ; ${}_{20}$ Ca.

${}_{22}Ti$: $({}_{18}Ar)\ 4s^2 3d^2$ — Period n = 4; Family IVB

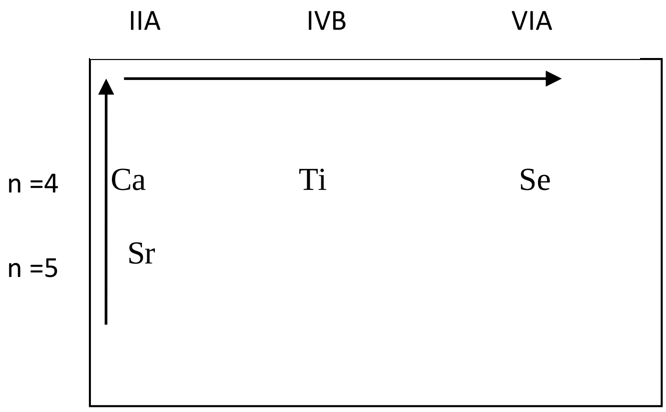
${}_{38}Sr$: $({}_{36}Kr)\ 5s^2$ — Period n = 5; Family IIA

$_{34}Se$: ($_{18}Ar$) $4s^2 3d^{10} 4p^4$ — Period n = 4; Family VIA

$_{20}Ca$: ($_{18}Ar$) $4s^2$ — Period n = 4; Family IIA

Elements in the periodic table:

- Variation of electronegativity in periodic table



The increasing order of electronegativity of the elements will be :

EN (Sr) < EN (Ca) < EN (Ti) < EN (Se)

Exercise n°5

a) Configuration of elements: ***Klechkowsky + class Configuration according to (n) ascending***

$_{51}Sb$: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6/\ \ 5s^2\ 4d^{10}\ 5p^3$

$_{51}Sb$: $1s^2\ 2s^2 2p^6\ 3s^2 3p^6\ 4s^2 3d^{10}\ 4p^6\ \ 5s^2\ 4d^{10}\ 5p^3$

Configuration

$_{28}Ni : 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$

$_{28}Ni : 1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$

Configuration

$_{12}Mg : 1s^2\ 2s^2 2p^6\ 3s$ ***Procession = configuration***

$_{33}As : 1s^2\ 2s^2 2p^6\ 3s^2 3p^6\ 4s^2 3d^{10}\ 4p^3$ ***Procession***

$_{33}As : 1s^2\ 2s^2 2p^6\ 3s^2 3p^6\ 4s^2 3d^{10}\ 4s^2 4p^3$

Configuration

$_{20}Ca : 1s^2\ 2s^2 2p^6\ 3s^2 3p^6\ 4s^2$ ***Procession = configuration***

$_{20}Ca : (_{18}Ar)\ 4s^2$

b) Position of elements in the periodic table

Element	***Simplified procession***	***Period***	***Family***
$_{51}Sb$	$[_{36}Kr]\ 5s^2 3d^{10}\ 5p^3$	**5**	VA
$_{28}Ni$	$[_{18}Ar] 4s^2 3d^8$	**4**	VIIIB ***(Triad)***
$_{12}Mg$	$(_{10}Ne)\ 3s^2$	**3**	IIA
$_{33}As$	$(_{18}Ar)\ 4s^2 3d^{10}\ 4p^3$	**4**	VA
$_{20}Ca$	$(_{18}Ar)\ 4s^2$	**4**	IIA
$_{38}Sr$	$[_{36}Kr]\ 5s^2$	**5**	IIA

c)

$_{51}Sb : [_{36}Kr]\ 5s^2 3d^{10}\ 5p^3$

valence shell **n = 5**

e- of core = **46**

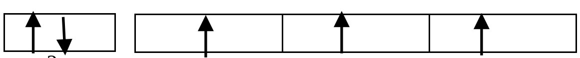
e- of valence = **5**

Subshells of external valences : 5s

Subshells of internal valences : 3d

d) ***The valence electrons of arsenic in quantum boxes***

$_{33}As : (_{18}Ar)\ 4s^2 3d^{10}\ 4p^3$ ***5 valence electrons***



$4s^2$ 4 p 3

n=4	n=4	n=4
ℓ =1	ℓ =1	ℓ =0
m= +1	m= 0	m= -1
s= + 1/2	s= +1/2	s= +1/2

e) ***The stable ions of*** $_{20}$***Ca et*** $_{12}$***Mg*** Ca^{2+} et Mg^{2+}

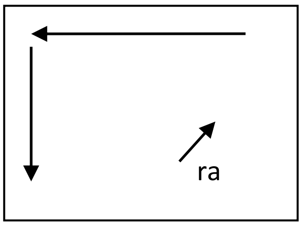
On a: $Ca \longrightarrow Ca^{2+} + 2e^-$ $Mg \longrightarrow Mg^{2+} + 2e^-$

$_{12}Mg$: $(_{10}Ne)\ 3s^2$ $_{12}Mg^{2+}$: $(_{10}Ne)\ 3s^0$ therefore Mg^{2+}: $(_{10}Ne)$ ***stable ion***

$_{20}Ca$: $(_{18}Ar)\ 4s^2$ $_{20}Ca^{2+}$: $(_{18}Ar)\ 3s^0$ therefore Ca^{2+}: $(_{18}Ar)$ ***stable ion***

f) ***The element with the largest atomic radius and the element with the smallest atomic radius***

The atomic radius varies in the periodic table as follows :,



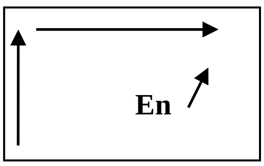
The elements are placed in the periodic table.

	IIA	VIIIB	VA
n=3	**Mg**		
n=4	Ca	Ni	As
n=5	Sr		**Sb**

The element with the largest atomic radius is ***Sb (antimony).***

The element with the smallest atomic radius is ***Mg (magnesium).***

g) Electronegativity varies across the periodic table as follows:



Of the elements in family IIA, the most electronegative is: **Mg**

EN (Mg) > EN (Ca) > EN (Sr)

f the elements in the 4^{th} period, the least electronegative is: **Ca**

EN (As) > EN (Ni) > EN **(Ca)**

h) ***Diamagnetic elements do not have unpaired electron s:*** $_{12}Mg$, $_{20}Ca$

Paramagnetic elements have unpaired electrons : $_{33}As$, $_{28}Ni$, $_{51}Sb$.

Exercise n°6

a) Conditions that must be verified by a AO: n ϵ IN **0 ≤ ℓ ≤ n-1 - ℓ ≤ n ≤ + ℓ**

	Atomic orbital names
$\psi(3,0,0)$	$3s_0$
$\psi(3,-1,0)$	*False because ℓ* does not check the condition
$\psi(3,1,-1)$	$3p_{-1}$
$\psi(4,3,-1)$	$4f_{-1}$
$\psi(2,2,2)$	*False because ℓ does not check the condition*
$\psi(4,2,-2)$	$4d_{-2}$

b) Name of AOs using the function Ψ(n, ℓ, m)

Atomic orbitals	***Atomic orbital names***
$3p_{-1}$	$\psi(3,1,-1)$
$3d_{-2}$	$\psi(3,2,-2)$
$3f_{-2}$	*False because ℓ does not check the condition*
$2s_0$	$\psi(2,0,0)$
$3p_0$	$\psi(3,1,0)$
$3d_{-2}$	$\psi(3,2,-2)$

Exercise n°7

1) ***Configuration = procession + classification of subshells according to n*** $\nearrow$

$_{37}Rb$: $1s^2\ 2s^2 2p^6\ 3s^2 3p^6\ 4s^2 3d^{10}\ 4p^6/5s^1$ ***Cortège***

$_{37}Rb$: $1s^2\ 2s^2 2p^6\ 3s^2 3p^6\ 3d^{10} 4s^2 4p^6\ 5s^1$

Configuration

$_{37}Rb$:[$_{36}Kr$] $5s^1$

$_{12}Mg$: $1s^2\ 2s^2 2p^6/3s^2$ ***Procession = configuration***

$_{12}Mg$: [$_{10}Ne$] $3s^2$

$_{13}Al$: $1s^2\ 2s^2 2p^6/3s^2 3p^1$ ***Procession = configuration***

$_{13}Al$: [$_{10}Ne$] $3s^2 3p^1$

$_{31}Ga$: $1s^2\ 2s^2 2p^6\ 3s^2 3p^6\ /4s^2 3d^{10}\ 4p^1$ ***Procession***

$_{31}Ga$: $1s^2 2s^2\ 2p^6\ 3s^2 3p^6\ 3d^{10} 4s^2 4p^1$

Configuration

$_{31}Ga$: [$_{18}Ar$] $4s^2 3d^{10}\ 4p^1$

$_{38}Sr$: $1s^2\ 2s^2 2p^6\ 3s^2 3p^6\ 4s^2 3d^{10}\ 4p^6/5s^2$ ***Procession***

$_{38}Sr$: $1s^2\ 2s^2 2p^6\ 3s^2 3p^6\ 3d^{10}\ 4s^2 4p^6 5s^2$

Configuration

$_{38}Sr$: [$_{36}Kr$] $5s^2$

$_{33}As$: $1s^2\ 2s^2 2p^6\ 3s^2 3p^6/4s^2 3d^{10}\ 4p^3$ ***Procession***

$_{33}As$: $1s^2\ 2s^2 2p^6\ 3s^2 3p^6\ 3d^{10}\ 4s^2\ 4p^3$

Configuration

$_{33}As$: [$_{18}Ar$] $4s^2 3d^{10}\ 4p^3$

$_{8}O$: $1s^2/2s^2 2p^4$ ***Procession = configuration***

$_{8}O$: [$_{2}He$] $2s^2 2p^4$

$_{84}Po$: $1s^2 2s^2 2p^6\ 3p^6\ 4s^2 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^6 / 6s^2 4f^{14}\ \ 5d^{10}\ \ 6p^4$ ***Procession***

Configuration

$_{84}Po$: $1s^2 2s^2 2p^6\ 3p^6\ 3d^{10}\ 4s^2 4p^6\ 4d^{10}\ 4f^{14}\ 5s^2\ 5p^6\ \ 5d^{10}\ 6s^2\ \ 6p^4$

$_{4}Po$: [$_{54}Xe$] $6s^2 4f^{14}\ 5d^{10}\ 6p^4$

$_{52}Te$: $1s^2 2s^2 2p^6\ 3s^2 3p^6\ 4s^2 3d^{10}\ 4p^6 / 5s^2\ 4d^{10}\ 5p^4$ ***Procession***

Configuration

$_{52}Te$: $1s^2 2s^2 2p^6\ 3s^2 3p^6\ 4s^2 3d^{10}\ 4p^6 / 5s^2\ 4d^{10}\ 5p^4$

$_{84}Te$: [$_{36}Kr$] $5s^2\ 4d^{10}\ 5p^4$

2) ***Position of elements in the periodic table***

$_{37}Rb$: [$_{36}Kr$] $5s^1$ —— n = 5 ***Period***

Ia ***Column***

$_{12}Mg$: [$_{10}Ne$] $3s^2$ —— n = 3

Family IIa

$_{13}Al$: [$_{10}Ne$] $3s^2\ 3p^1$ —— n = 3

Family IIIa

$_{31}Ga$: [$_{18}Ar$] $4s^2 3d^{10}\ 4p^1$ —— n = 4

Family IIIa

$_{38}Sr$: [$_{36}Kr$] $5s^2$ —— n = 2

Family IIa

$_{33}As$: [$_{18}Ar$] $4s^2 3d^{10}\ 4p^3$ —— n = 4

Family Va

$_{8}O$: [$_{2}He$] $2s^2 2p^4$ —— n = 2

Family VIa

$_{52}Te$: [$_{36}Kr$] $5s^2 4d^{10} 5p^4$ —— n = 5

Family VIa

$_{84}Po$: [$_{54}Xe$] $6s^2 4f^{10} 5d^{10} 6p^4$ —— n = 6

Family VIa

3) We note that:

$_{8}O, _{52}Te$, $_{84}Po$ belong to the same Family VIa as oxygen, the stable ions will be :

$_{8}O^{-2}$ structure of ($_{10}Ne$) ; $_{52}Te^{-2}$ structure of ($_{54}Xe$) ; $_{84}Po^{-2}$structure of ($_{86}Rn$).

$_{12}Mg$ et $_{38}Sr$ belong to the same Family IIa, the stable ions will be:

$_{12}Mg^{2+}$($_{10}Ne$) et $_{38}Sr^{2+}$($_{36}Kr$)

$_{37}Rb$: belongs to the same Family Ia, the stable ion will be $_{38}Rb^{+}$ ($_{36}Kr$)

4) $_{84}Po$: [$_{54}Xe$)] $6s^2 4f^{14} 5d^{10} 6p^4$

The core electrons = 54 + the electrons of the internal subshells when they are saturated.

Therefore : 54 + 14 +10 = 78 e-

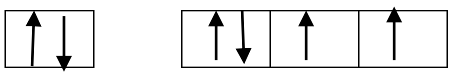
The e- of valence = 6 e-

The shell of valence : n = 6

The internal valence subshells : 4f, 5d

The external valence subshells: $6s^2 6p^4$

The valence electrons in quantum boxes



Exercise n°8

X has less than 20 e- and 2 unpaired e-, X can have the following electronic structures:

X : $1s^2 2s^2 2p^4$ Z = 8 $\boxed{\uparrow\downarrow}\boxed{\uparrow}\boxed{\uparrow}$ $2p^4$

X : $1s^2 2s^2 2p^6 3s^2 3p^4$ Z = 16 $\boxed{\uparrow\downarrow}\boxed{\uparrow}\boxed{}$ $3p^4$

X : $1s^2 2s^2 2p^2$ Z = 6 $\boxed{\uparrow}\boxed{\uparrow}\boxed{}$ $2p^2$

X : $1s^2 2s^2 2p^6 3s^2 3p^2$ Z = 14 $\boxed{\uparrow}\boxed{\uparrow}\boxed{}$ $3p^2$

X belongs to the period of $_{11}Na$: ($_{10}Ne$) $3s^1$ therefore ***n* = 3**

X belongs to the Family $_{34}Se$: ($_{18}Ar$) $4s^2 3d^{10} 4p^4$ ⇒ ***the Family VIa***

The structure of X will therefore end in the form : **$3s^2 3p^4$**

We then establish the procession of X.

X: $1s^2 2s^2 2p^6 3s^2 3p^4$ Z = 16 It's about sulfur. $_{16}S$

Exercise n°9

1) X $\longrightarrow$ X^+ + 1e-

The ion X^+ has the same structure as e ($_{18}Ar$) Therefore ***Zx = 19 (Potassium)***

X + 1e- $\longrightarrow$ X^-

The ion X^- has the same structure as ($_{18}Ar$) Therefore ***Zx = 17 (Chlore)***

2) X belongs to the column VIa and to the 4^{th} period :

$$\left.\begin{array}{r}\text{Column VIa} \Rightarrow ns^2\ np^4 \\ \text{period n} = 4\end{array}\right\} \Rightarrow \text{The structure}$$ of X will end in the form : ***4s2 4p⁴***

We establish the procession of X.

X: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^4$ therefore ***Z = 34 (Selenium)***

3) X belongs to the period of $_{3}Li$**:** ($_{2}He$) $2s^1$ ⇒ X belongs to the period ***n = 2***

X belongs to the family of $_{33}As$**:** ($_{18}Ar$) $4s^2$ $3d^{10}$ $4p^3$ ⇒ X belongs to the family Va

The structure of X will end in the form: ***2s2 4p³***

We establish the procession of X.

X: $1s^2 2s^2 2p^6$ therefore ***Z = 10 (Argon)***

Exercise n°10

1) A) Situation of the elements in the periodic table

To locate the elements in the periodic table, we establish the electronic procession according to the Klechkowski diagram, then we write the procession using noble gasses. .

We will therefore have:

Element	*Simplified procession*	*Period*	*Family*
$_{56}Ba$	[$_{54}Xe$] $6s^2$	**6**	IIA
$_{27}Co$	[$_{18}Ar$] $4s^2$ $3d^7$	**4**	VIIIB ***(Triad)***
$_{20}Ca$	[$_{18}A$] $4s^2$	**4**	IIA
$_{34}Se$:	[$_{18}Ar$] $4s^2$ $3d^{10}$ $4p^4$	**4**	VIA

B) The stable ions of calcium and selenium

We have : Ca $\longrightarrow$ $\mathbf{Ca^{2+}}$ + $2e^-$

Se + $2e^-$ $\longrightarrow$ $\mathbf{Se^{2-}}$

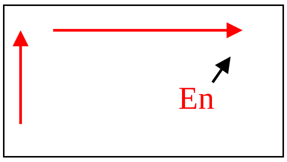
Stable ions will be :

$_{20}Ca^{2+}$: [$_{18}Ar$] stable ion of calcium

$_{34}Se^{2-}$: [$_{36}Kr$] stable ion of selenium

C) Ranking in ascending order of electronegativity

Electronegativity (En) varies in the periodic table as follows :



We put the elements on the board.

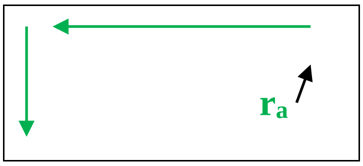
	IIA	VIIB	VIA
n = 4	**Ca**	Co	Se
n = 6	Ba		

Therefore the increasing ranking of electronegativity :

En (Ba) < En (Ca) < En (Co) < En (Se)

D) the atomic radius r_a :

The atomic radius varies in the periodic table as follows:



Therefore calcium (Ca) has the largest atomic radius.

E)

1)

$$\left.\begin{array}{l} \text{X belongs to the 3rd period} \Rightarrow \quad n = 3 \\ \text{X belongs to the family } V_A : ns^2np^3 \end{array}\right\}$$

The structure of X will end in the form: ***3s2 3p³***

We then establish the procession of X.

X : $1s^2 2s^2 2p^6 3s^2 3p^3$ ***Z = 15 (Phosphorus)***

2)

$$\left.\begin{array}{r} \text{X belongs to the 5th period} \Rightarrow \quad n = 5 \\ \text{X belongs to the Boron column} \quad {}_{5}B : [\,{}_{2}He]\, 2s^2 2p^1 \end{array}\right\} \quad :$$

The structure of X will end in the form : $\boldsymbol{5s^2 5p^5}$

We then establish the procession of X.

X: $1s^2 2s^2 2p^6\, 3s^2 3p^6\, 4s^2 3d^{10}\, 4p^6\, 5s^2\, 4d^{10}\, 5p^1$ ***Z = 49 (Indium)***

Exercise n°11

The atomic number of the elements X and Y :

a) X^{3+} possesses the structure of (${}_{10}Ne$) $\Rightarrow X^{3+}$: $1s^2 2s^2 2p^6$

$X \longrightarrow X^{3+} + 3\,e^-$ therefore ***Zx = 13 (Aluminium)***

b) Y belongs to the same period as ${}_{13}X$ **:** $[{}_{10}Ne]\, 3s^2 3p^1$

$\Rightarrow$ Period of Y is ***n = 3***

In period 3, there are 18 elements, the last element is (${}_{18}Ar$) , element Y is missing two electrons to have the structure of Argon. $\Rightarrow$ ***Zy = 16 (Sulphur)***

Exercise n°12

The atomic number of vanadium is Z = 23. The electron configurations of the element vanadium and the ions considered are as follows:

${}_{23}V$: $1s^2 2s^2\, 2p^6\, 3s^2\, 3p^6\, 4s^2 3d^3$

${}_{23}V^{2+}$: $1s^2 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^3$

${}_{23}V^{5+}$: $1s^2 2s^2\, 2p^6\, 3s^2\, 3p^6$

The configuration of V^{5+} is identical to that of Ar, particularly stable since the n = 3 level is filled . This ion is therefore more stable than V^{2+} which has 3 unpaired electrons in 3 d orbitals. We can therefore see that the octet rule does not always apply to transition metals.

Exercise n°13

The electrons of copper that are characterized by the magnetic quantum number
m = +1 :

We also refer to the rules that connect the 4 quantum numbers to each other. :

The principal quantum number **(n)** verifies : $n \in N^*$
The secondary quantum number (ℓ) verifies : $0 \leq \ell \leq n-1$
The magnetic quantum number **(m)** verifies : $-\ell \leq m \leq +\ell$
The spin checks: S = $\pm$ 1/2

By applying these rules to the relevant energy levels, we obtain the answer to this question.

Copper corresponds to Z = 29 and the corresponding electronic configuration is as follows:

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^1$

By explicating the 4 levels of the 4th period, we write:

n = 1	$\ell = 0$	$m = 0$	no electron with $m = +1$
n = 2	$\ell = 0$	$m = 0$	no electron with $m = +1$
	$\ell = 1$	$m = -1,0,+1$	2 electrons with $m = +1$
n = 3	$\ell = 0$	$m = 0$	no electron with $m = +1$
	$\ell = 1$	$m = -1,0,+1$	2 electrons with $m = +1$
	$\ell = 2$	$m = -2,-1,0,+1,+2$	2 electrons with $m = +1$
n = 4	$\ell = 0$	$m = 0$	no electron with $m = +1$

In total, copper, in its ground state, has 6 electrons characterized by the quantum number

$m_\ell = +1$

Exercise n°14

The period and the column of the elements whose atomic numbers are respectively 8 and 19.Z = 8

The electronic procession of the element is:

$_{8}X$: $1s^2$/ $2s^2$ $2p^4$

$_{8}X$: [$_{2}He$] / $2s^2$ $2p^4$ → Period n = 2 ; Family VIA it's Oxygen.

Z = 19

The electronic procession of the element is :

$_{19}X$: $1s^2$ $2s^2$ $2p^6 3s^2$ $3p^6$ /$4s^1$

$_{19}X$: [$_{18}Ar$] $4s^1$ → Period n = 4 ; Family IA It's Potassium

Tutorial 4
(chemical bonds)

Exercise n°1 **

The HCl molecule has a dipole moment equal to 1.03 Debye and a bond length of d = 1.27A°.

1) Calculate the partial charge of this bond. Indicate the direction of the moment of this bond.

2) Calculate the ionic percentage of this bond. Discuss.

3) Classify the following bonds in decreasing order of polarity : HF, OH et H-Br.

Exercise n°2***

Give the Lewis diagrams of:

1) Compounds: a) $AlCl_3$; b) HClO ; c) $HClO_2$; d) $HClO_3$.

2) Ions: a) $(ClO_3)^-$; b) $(ClO_4)^-$; c) $(CO_3)^{2-}$.

3) What are the elements in these molecules that do not follow the octet rule?.

Data : $_1H$, $_6C$ $_8O$, $_{13}Al$, $_{17}Cl$.

Exercise n°3**

Give the hybridization of the atoms of the molecules, indicate the geometry as well as the angles.

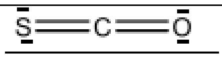
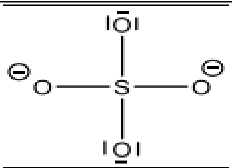
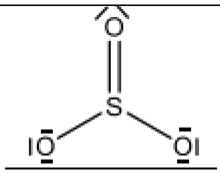
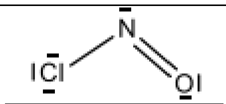
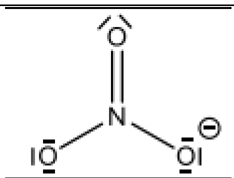
H_2O ; $\overline{N}H_3$; $CH_3\overline{N}H_2$; $CH_2=O$; $CH_2=C=CH_2$; $CH_3-CH_2-\underset{\|}{C}(=O)-\underset{|}{CH}(OH)-NH_2$

Exercise n° 4 *

The dipole moment of the Li - H bond is μ = 5.88 Debyes. Its partial ionic character is 77%. Calculate the bond length.

*Exercise n°5***

Complete the following table: We are given: $_{1}H$, $_{5}B$, $_{6}C$, $_{7}N$, $_{8}O$, $_{9}F$, $_{16}S$, $_{17}Cl$

Chemical species	Lewis diagram	AXmEn	Geometry
OCS			
SO_4^{2-}			
SO_3			
NOCl			
NO_3^-			

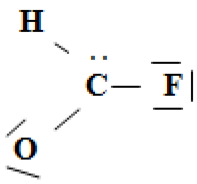
*Exercise n°6***

The following Lewis structures are incorrect, correct them.

Data : $_{1}H$ $_{6}C$ $_{7}N$ $_{8}O$ $_{9}F$

a) $H-\overline{C}=\underline{\overline{N}}$

d)



b) $H=C=C=H$

c) $\underline{\overline{O}}-C-\underline{\overline{O}}$

e) $H-\overline{O}=\underline{\overline{F}}|$

Exercise n°7**

Indicate the type of bond (σ s-s, σ s-p, σ p-p) in the following molecules.:

HF, F_2, H_2, O_2.

Exercise n°8**

Give the hybridization of the atoms of the following molecules, as well as the Gillespie formula of the molecules, specifying their geometry.

$H_2\mathbf{O}$, $|\mathbf{N}H_3$, $\mathbf{C}H_2{=}O$, $H\mathbf{C}{\equiv}N|$, $CH_2{=}\mathbf{C}{=}CH_2$

Data : $_{1}H$, $_{4}Be$, $_{6}C$, $_{7}N$, $_{8}O$, $_{15}P$, $_{16}S$, $_{17}Cl$

Tutorial 4 Solutions

Exercise n° 1

The partial charge of the bond

μ (HCl) = 1.03 Debyes   1 Debyes = 0.33 10^{-29}Coulombs-Meters

1) μ (HCl) = δ. d $\Rightarrow$ $\delta = \frac{\mu}{d} = \frac{1.03x0.33\ 10^{-29}}{1.27\ x\ 10^{-10}}$

δ = 2.67 10^{-20} Coulombs

The dipole moment is oriented from the negative pole toward the positive pole. $H^{+\delta} \longleftarrow Cl^{-\delta}$

2) ***Ionic percentage of HCl***

% ionic $= \frac{\mu_{exp}}{\mu_{iereo}}$ x 100 = $\frac{\delta}{e}$ x 100

Ionic percentage of HCl $= \frac{2.67\ 10^{-20}}{1.6\ 10^{-19}}$ x 100

Therefore : ***% ionic HCl = 16.68 %***

This indicates that ***16.68***% of the HCl bond is ***ionic***, the rest, that is

100 – 16.68 = ***83.32 %*** **the bond is *polarized covalent.***

3) According to the electronegativity of the elements, we have: En (F) > En (Cl) > En (Br)

Therefore the decreasing order of polarity will be: HF > HCl >HBr

HF > HCl >HBr

The more electronegative the atom, the more polarized the bond.

Exercise n° 2

1) Lewis structure of compounds

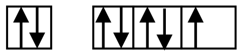
a) $AlCl_3$

$_{13}Al$: ($_{10}Ne$) $3s^2\ 3p^1$

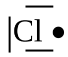
$_{13}Al$: ($_{10}Ne$) [↑↓] [↑| |]   Therefore the atom will be : $\overline{\text{Al}}$ •

$_{13}Al^*$: ($_{10}Ne$) [↑] [↑|↑|]   • Al ▯ (with one dot above and one below)

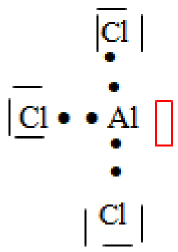
$_{17}Cl$: ($_{10}Ne$) $3s^2$ $3p^5$



Therefore the atom will be :



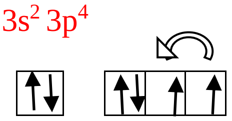
The Lewis structure will be :



b) HClO

$_8O$: ($_2He$) $3s^2$ $3p^4$

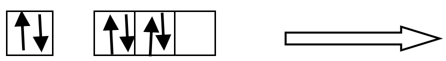
$_8O$: ($_2He$)



$3s^2$ $3p^4$

Excited oxygen is obtained.

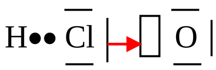
O* : ($_2He$)



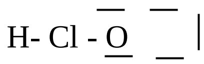
$_1H$: $1s^1$

1H : H•

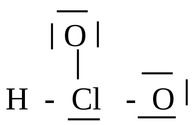
Therefore, the Lewis structure will be :



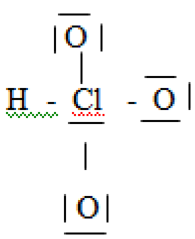
Finally :



c) $HClO_2$



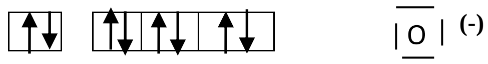
d) $HClO_3$



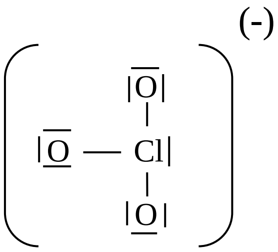
2) *Lewis structure of ions*

a) ClO_3^- **:**

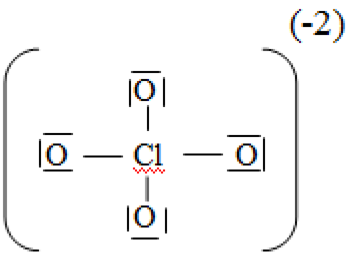
Lewis structure of atoms : |Cl• ; • O •

$_8O^-$: ($_2$He) 

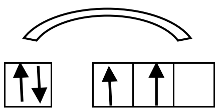
$_8O^*$: |O▯

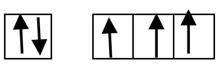


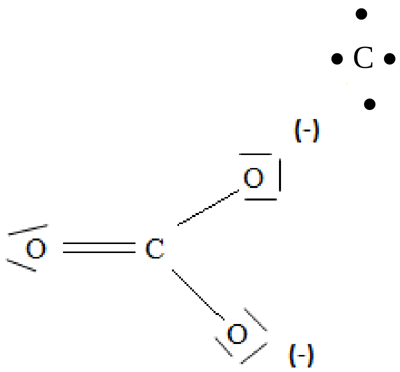
b) ClO_4^-



c) CO_3^{-2}

$_6C$: ($_2$He) 

$_6C^*$: ($_2$He) 

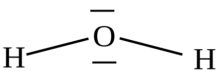


3) The element aluminium (Al) does not obey the octet rule because it is surrounded by 10 electrons..

Exercise n° 3

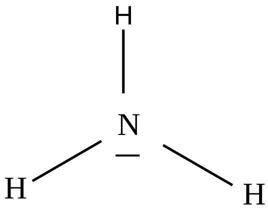
Hybridisation of molecules' atoms

H_2O



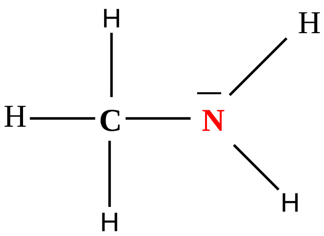
Sp^3 Tetrahedron angle 109°28'

NH_3



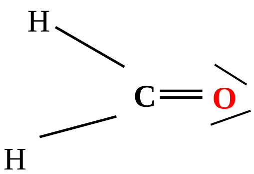
sp^3 Tetrahedron angle 109°28'

CH_3NH_2



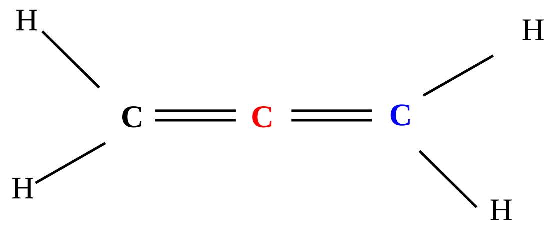
sp^3 Tetrahedron angle 109° 28' ***sp^3 Tetrahedron angle 109° 28'***

$CH_2= O$



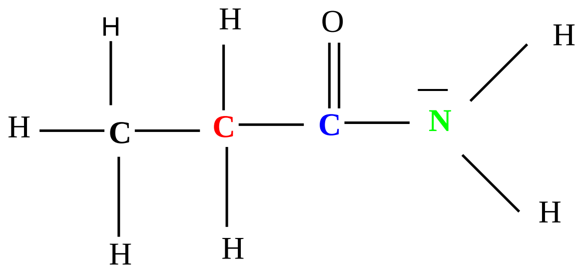
sp^2 Plane triangle angle 120° ***sp^2 Plane triangle angle 120°***

$CH_2=C=CH_2$



sp^2 Plane triangle angle 120° ***sp Linear angle 180°*** ***sp^2 Plane triangle angle 120°***

$CH_3 – CH_2 – CO– CH(OH) – \bar{N}H_2$



sp^3 Tetrahedron angle 109°28' ***sp^2 Plane triangle angle 120°***

sp^3 Tetrahedron angle 109°28' ***sp^2 Plane triangle angle 120°***

Exercise n° 4

The length of the bond Li-H

The dipole moment μ= 5.88 Debyes and the ionic character = 77%

We know that :

$$C\% = \frac{\mu_{exp}}{\mu_{theo}} 100 = \frac{\mu_{exp}}{e \, . \, d} 100$$

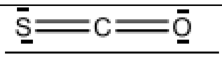
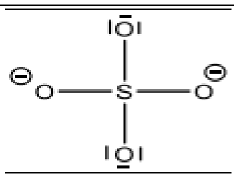
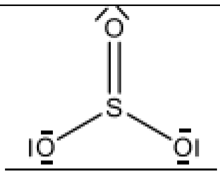
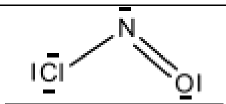
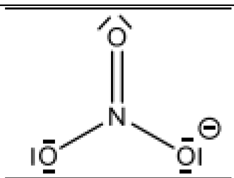
Therefore the length of the bond will be :

$$d = \frac{5.88 \, . \, 0{,}33 \, 10^{-29}}{1.6 \, 10^{-19} \, . \, 0.77} = 1.575 \, 10^{-10} \text{ m} = 1.58 \text{ A°}$$

d* = 1.58 *A°

Exercise n° 5

We complete the following table:

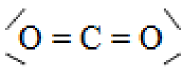
Chemical species	***Lewis diagram***	***AXmEn***	***Geometry***
OCS		AX_2	Linear α = 180°
SO_4^{2-}		AX_4	Tetrahedron α = 109° 28’
SO_3		AX_3	Plane Triangle α = 120°
NOCl		AX_2E	V-shaped molecule α < 120°
NO_3^-		AX_3	Plane Triangle α = 120°

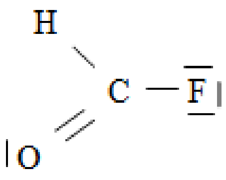
Exercise n° 6

The correct Lewis structures of the molecules will be :

a) H − C ≡ N |

b) H − C ≡ C − H

c) 

d) 

e) H − $\overline{\underline{O}}$ − $\overline{\underline{F}}$|

Exercise n°7

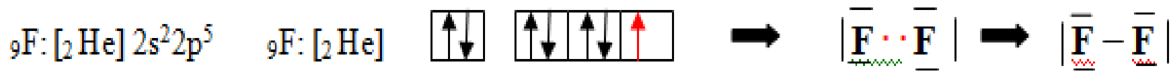
To indicate the type of bond (σ s-s, σ s-p, σ p-p) in molecules : HF, F_2, H_2, O_2, we must establish the Lewis structure

H_2 :

$_1H : 1s^1 \;\; H^{\bullet} \;\; \Rightarrow \;\; H^{\bullet\bullet}H \;\; \Rightarrow \;\; H-H$

The two electrons that form the bond σ in the molecule H_2 are each located in atomic orbitals of type s, so the bond is a σ s-s

F_2 :

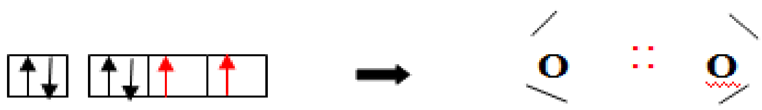


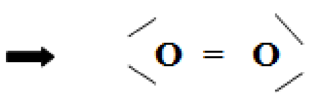
The two electrons that form the σ bond in the F_2 molecule are each located in atomic orbitals of type p, so the bond is a σ p-p

HF: The Lewis structure of the HF molecule is**: $\mathbf{H - \overline{\underline{F}}|}$**

The two electrons that form the σ bond in the HF molecule are located in atomic orbitals of type s (for hydrogen) and in a p orbital (for fluorine), so the bond is a σ s-p**.**

O_2: $_8O$: [$_2$He] $2s^2p^4$ $\quad$ $_8O$:[$_2$He]





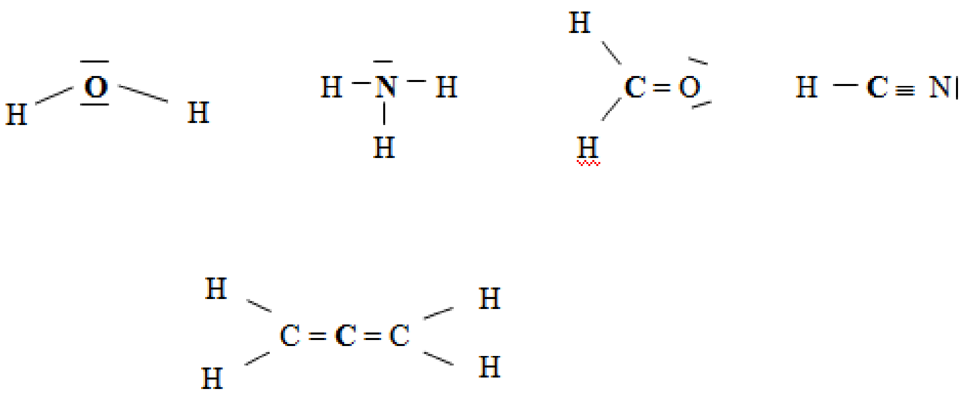
The double bond is formed by a σ bond and a π bond. The two electrons that form the σ bond in the O_2 molecule are each located in atomic orbitals of type p, so the bond is a σ p-p. Moreover, the two electrons that form the bond must necessarily be in a p-type atomic orbital, so the bond will be a π p-p.

Exercise n°8

The hybridization of atoms in molecules

H_2O - $|NH_3$ - $H_2C{=}O$ $HC{\equiv}N|$, $CH_2{=}C{=}CH_2$

The detailed Lewis structures will be



- In the **H_2O** molecule, the central oxygen atom forms two σ bonds and has two non-bonding doublets (equivalent to σ bonds), so it is **sp^3** hybridised and the molecule will be spatial. Applying Gillespie's rule, the **H_2O** molecule will be an AX_2E_2, therefore a V-shaped tetrahedral derivative (spatial molecule) with an angle < 109°28'.

- In the NH_3 molecule, the nitrogen central atom makes three σ bonds and has one non-bonding doublet, it is therefore sp^3 hybridised and the molecule will be spatial. Applying Gillespie, the NH_3 molecule will be an AX_3E_1, therefore a trigonal pyramid with an angle < 109°28'.

- In the $H_2C{=}O$ molecule, the central carbon atom forms three σ bonds and one π bond, so it is sp^2 hybridised and the molecule will be planar. Applying Gillespie's method, the CH_2O molecule will be AX_3, therefore a planar triangle with an angle equal to 120°

.

- In the HCN molecule, the central carbon atom forms two σ bonds and two π bonds, so it is sp hybridised and the molecule will be linear. Applying Gillespie's formula, the HCN molecule will be an AX_2, therefore axial with an angle equal to 180°.

- In the molecule $H_2C = C = CH_2$, the central carbon atom forms two σ bonds and two π bonds, so it is sp hybridised and the molecule will be linear. Applying Gillespie's rule, the molecule $H_2C = C = CH_2$ will be an AX_2, therefore axial with an angle equal to 180°.

MCQ

Structure of matter
&
Chemical bonds

MCQ 1

1- Let's say 2 grams of zinc (**Zn**: 63.38), 1.2 x 10^{22} atoms of argon (Ar: 39.94), and 2.4 10^{23} molecules of CH_4 [**C**: 12 **H**: 1]. The compound that contains the largest number of moles is:

A: zinc **B**: CH_4 **C**: argon **D**: No answer is true.

2- Let's say there are 0.45 moles of $CaSO_4$ (**Ca**: 40 **S**: 32 **O**: 16):

A: the mass of $CaSO_4$ is: 61.2g **B**: the number of molecules is: 7.2 10^{24}

C: the number of oxygen atoms is: 1.08 10^{24} **D**: NAT.

3- A) The flaw in Thomson's atomic model is the existence of the vacuum.

B) the energy of the electron on the orbit is constant in Bohr's model.

C) The nucleus with the highest binding energy is the most stable

D) The Rutherford model is the planetary model, and the flaw in Bohr's theory is that it is limited.

4 – 5 – 6 : Let the following table :

The nucleus	**Experimental mass (amu)**	**Mass defect (Δm) (amu)**	**Bond energy (ΔE) (Mev)**	**Binding energy per nucleon (a)**
^{16}O	**A**	0.01369	**b**	**C**
^{11}B	11.00656	**D**	**e**	**F**

Data: mp ***(masse of proton)*** = 1.007278 amu mn = 1.008665 amu ***(mass of neutron)***

4- A: a = 16. 3471 **B:** b = 12.74 **C:** c = 0.97 **D:** NAT *(*No answer is true*)*

5- A: d = 0. 08182 **B:** e = 67.174 **C:** f = 6.92 **D:** NAT

6- A: oxygen is the most stable nucleus **B**: boron is the most stable nucleus **C**: oxygen is diamagnetic **D**: boron is monovalent.

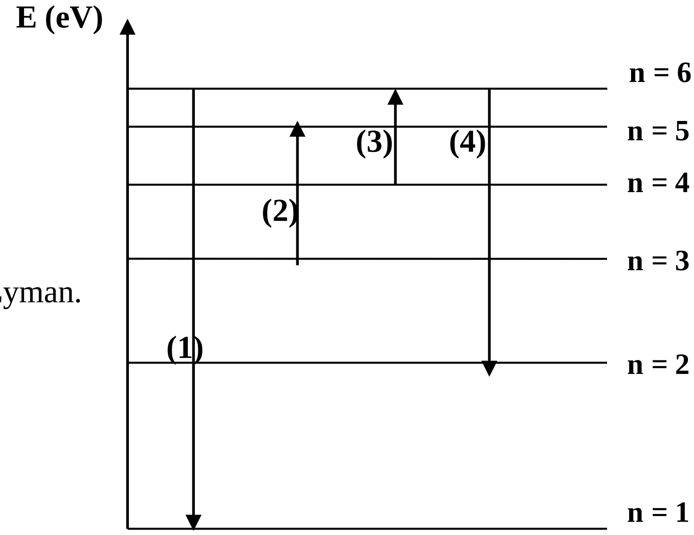
7- Let's consider a particle with a mass of m = 6.6×10^{-17} kg, moving at a speed of $v = 1.3 \times 10^5$ m.s^{-1}; we denote λ its wavelength, ν its frequency, and ΔE its energy.

A: $\lambda = 7.71\ 10^{-23}$ m. **B:** $\nu = 3.89\ 10^{30}$ s^{-1} **C:** $\Delta E = 2.,57\ 10^{-3}$ Joules **D:** $\lambda = 1/\nu$

8- Among the following photons, which one is likely to cause the transition of an electron from the second excited level of $_4Be^{3+}$ to the third excited level?

A: 5. 95 eV **B:** 30 eV **C:** 12. 68 eV **D:** 10. 5 eV

9- Consider the following energy diagram for the hydrogen atom:



A : The ray(4) is in the visible.

B : the ray(3) is a Pfund ray

C : the line(1) is the 5th emission line of Lyman.

D : the ray(2) is in ultraviolet

10- A : The first line of a series corresponds to the shortest wavelength. **B**: The emission spectrum is discontinuous **C**: Ionization corresponds to the last line of a series **D :** Rn = 10^4 Ra

11-13 Let it be technetium $_{43}Tc$:

11- He possesses: **A**: two outer valence layers **B**: an inner valence layer **C**: the valence layer is: N **D**: Gives a stable ion X^{2+}.

12- Technetium is **A :** paramagnetic **B :** possesses a lower electronegativity and a larger atomic radius than those of $_{40}Zr$. **C :** belongs to the family VIIB **D:** possesses a higher electronegativity and a smaller atomic radius than those of $_{40}Zr$.

13- The element X belongs to the Tc family and the 4^{th} period, the atomic number of X is :

A : 41 **B** : 74 **C** : 25 **D** : NAT.

14- What are the correct statement(s): **A:** n = 3; l = 0; m = 0 ; s = +1/2

B: n= 2; l= 2; m= 1; s= -1/2 **C:** n= 4; l= 1; m= -2; s= -1/2 **D:** n= 4; l=2; m= 0; s= +1/2

15- A : element 93Np is a transuranic. **B :** Non-metals are electropositive. **C :** the metallic character varies like the atomic radius in the periodic table. **D :** NAT.

16 – 17 The dipole moment of the LiH bond is equal to 5.88 Debyes, its ionic percentage is 77%**.**

Context: We are given: e = $1.6\ 10^{-19}$ coulombs ; 1 Debye = $0.33\ 10^{-29}$ coulombs meters

16 - The partial load (coulombs) est : **A :** $1.20\ 10^{-20}$ **B :** $1.23\ 10^{-19}$ **C :** $1.68\ 10^{-21}$ **D :** NAT

17- The length of the bond is: **A :** 1.57 A° **B :** 1.67 A° **C :** 1.47 A° **D :** 1.86

18 – 20 Let the following molecules be: (the central atom in bold and underlined)

$\underline{\mathbf{B}}F_3$ $\underline{\mathbf{N}}O_3^-$ $H_2C{=}\underline{\mathbf{C}}H - F$ [$_1H$ $_5B$ $_6C$ $_7N$ $_8O$ $_9F$]

18 - $\underline{\mathbf{B}}F_3$: **A :** AX_3E **B :** does not respect the octet **C :** Hybridized sp^2 **D :** spatial

19- $\underline{\mathbf{N}}O_3^-$: **A :** flat **B :** AX_3 **C :** exists in two conjugated forms **D :** makes three (σ) and one (π) bond

20- $H_2C{=}\underline{\mathbf{C}}H – F$: **A :** AX_3 **B :** linear **C :** conjugated molecule **D :** does not respect the octet

(NAT : No answer is true)

MCQ1 Solutions

	A	B	C	D
1		X		
2	X		X	
3		X		X
4		X		
5	X		X	
6		X		X
7	X	X	X	
8				X
9	X		X	
10		X	X	
11		X		X
12	X		X	X
13			X	
14	X			X
15	X		X	
16		X		
17	X			
18		X	X	
19	X	X	X	X
20	X		X	

MCQ2

1- A) The homogeneous mixture forms a phase. **B)** a pure compound is formed of identical atoms and non-identical molecules. **C)** The water-sand system is a homogeneous mixture. **D)** the mass of a molecule of NaOH is $6.64\ 10^{-23}$g (Na : 23g O : 16g H : 1g) **E)** diamond and carbon are simple pure substances.

2- Let's say there is a mass of 4 g of calcium oxalate. CaC_2O_4 (Ca : 40g C : 12g), it corresponds to :

A) $3.76\ 10^{22}$ atoms of oxygen. **B)** 0.03125 moles of CaC_2O_4. **C)** 0.01251 moles.
D) $7.52\ 10^{22}$ atoms of carbon. **E)** 1.8810^{22} molecules of CaC_2O_4.

3- Let the following nucleuses:

Nucleus	**a**	**b**	**c**	**d**	**e**	**f**
Mass number	**36**	**56**	**40**	**58**	**35**	**40**
number of neutrons	**18**	**30**	**20**	**32**	**18**	**22**

A) (c- f) possess the same number of **B)** (b - f) isotones **C)** (a – f) isotopes **D)** (b-d) have the same number of protons **E)** (b - e) isobars.

4 – 7 Let the nucleus $^{235}_{92}$**U** its experimental mass is: 234.9942 amu.
(mp = 1.007278 amu, mn = 1.008665 amu).

4- The theoretical mass (amu) is :

A) 233.2564 **B)** 231.9210 **C)** 236.9086 **D)** 235.1584 **E)** 234.224

5- The mass defect (amu) is :

A) 0.0428 **B)** 1.0056 **C)** 0.0235 **D)** 1.3636 **E)** 1.9144

6) The binding energyin Joules is:

A) $2.42\ 10^{-11}$**B)** $3.55\ 10^{-10}$**C)** $1.02\ 10^{-11}$**D)** $2.86\ 10^{-10}$**E)** $2.02\ 10^{-11}$

7- The binding energy per nucleon (Mev/nucleon) is:

A) 7.58 **B)** 5.78 **C)** 7.85 **D)** 5.87 **E)** 8.75

8- A) The emission spectrum is non-continuous in the Rutherford atom..

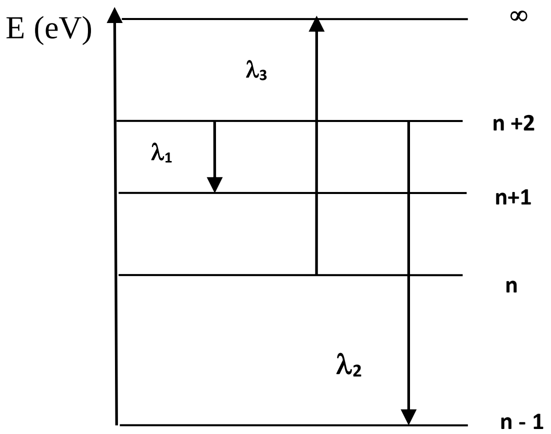
B) The relationship $r_n = r_0\ n^2$ allows for the calculation of the radius of a nucleus.

C) Matter is lacunar because Ra = 104 Rn

D) There are four Bohr postulates.

E) Thompson's atomic model is the planetary model.

9 – 14 Let the transitions of the electron of a hydrogen atom be represented on the energy diagram.:



Knowing that (n + 1) corresponds to the fundamental state of Brackett:

9 - The radius of the (n+2) orbit in A° is :

A) 12.35 **B)** 12.53 **C)** 13.55 **D)** 13.52 **E)** 13.25

10 - The energy of the orbit (n) in eV is:

A) – 3.4 **B)** – 1.51 **C)** -0.85 **D) -**13.6 **E)** – 0.544

11 - The speed of the electron on the (n-1) orbit in (m/s) is:

A) $2.34\ 10^{4}$ **B)** $1.42\ 10^{5}$ **C)** $1.09\ 10^{6}$ **D)** $2.89\ 10^{6}$ **E)** $1.33\ 10^{5}$

12 - A) λ_1 = 40404 A° **B)** λ_1 = 18701 A° **C)** λ_1 is in IR
D) λ_1 corresponds to the first emission line of Brackett **E)** $\Delta E(1) = - 4.9\ 10^{-20}$ Joules

13 - A) λ_2 = 4632 A° **B)** λ_2 = 4329 A° **C)** λ_2 is found in UV
D) λ_2 corresponds to the 3rd Paschen emission line **E)** $\Delta E(2) = - 2.856$ eV

14 –

A) (n+2) corresponds to the 2nd excited state of Paschen

B) λ_2 is the 4th emission line of Balmer

C) λ_3 is the last Paschen line

D) $\Delta E(3) = - 1.51$ eV

E) λ_3 corresponds to the ionization line.

15) The ionization energy of a hydrogenoid from the ground state is 54.4 eV. The atomic number (Z) of the hydrogenoid is:

A) 5 **B)** 3 **C)** 4 **D)** 2 **E)** 1

16 - For the quantum number n = 4, it corresponds:

A) 18 electrons **B)** 32 electrons **C)** 3 under layers **D)** 18 atomic orbitals **E)** 16 OA

17 - The number of electrons characterized by quantum numbers: n = 3, m = 0 est :

A) 2 **B)** 10 **C)** 6 **D)** 18 **E)** 12

18 - Let the following atomic orbitals:

(a) Ψ (3,0,0) **(b)** Ψ (2,2,0) **(c)**Ψ(0,0,0) **(d)**Ψ(2,1,- 1) **(e)** Ψ(3,1,- 2) **(f)** Ψ(4,3,0)

A) (a – b) exist **B)** (b – c) don't exist **C)** (e) exists **D)** (d) = $2p_{-1}$ **E)** (f) = $4d_0$

19) Let the electronic structure of Y^{3+} **:** [Kr] $5s^2\ 4d^{10}\ 5p^1$

A) The atomic number of Y is: 52
B) Y has 46 core electrons and 3 valence electrons.

C) He is bivalent and paramagnetic.

D) He belongs to the block d.

E) He has 2 external valence subshells and one internal valence subshell.

20 - A) The periodic table is composed of 32 columns and 7 periods

B) The periodic table is divided into four blocks

C) the lanthanides correspond to the filling of the 5f

D) Boron and silicon are semiconductors

E) The triad is composed of three columns.

21 – 22 Let the elements : $_{55}Cs$; $_{35}Br$; $_{19}K$; $_{24}Cr$

21- The element with the greatest metallic character is:

A) Br **B)** K **C)** Cs **D)** Cr **E)** Cs et Cr

22- A) Br is a non-metal

B) All the elements are monovalent

C) Cs is the least electronegative

D) The Cr^{+4} ion exists

E) Br has the smallest atomic radius

23 - Let's consider the HF molecule, its dipole moment is 0.88 Debye and d = 1.63A°.

A) The moment is oriented from F to H

B) The bond is a σ_{s-p}

C) The bond is a σ_{p-p}

D) 11.13% of the bond is ionic

E) 13.11% of the bond is ionic

24 -25 – 26 – 27 Let the elements : **P**F_3 **S**O_3 H_3**O**$^+$ **N**O_2^-*(central atom in bold)*

24) PF_3 **: A)** AX_3E_1 **B)** AX_2E_2 **C)** $\alpha< 120°$ **D)** axial **E)** triangular pyramid

25) SO_3 : **A)** AX_2E_2 **B)** equilateral triangle **C)** AX_3 **D)** AX_3E_1 **E)** axial

26) H_3**O**$^+$: **A)** AX_4 **B)** AX_2E_2 **C)** AX_3 **D)** there is a dative link **E)** triangle

27) NO_2^- **A)** Tetrahedron **B)** AX_3E_1 **C)** AX_2E_1 **D)** $\alpha< 109° 28'$ **E)** $\alpha< 120°$

Data : $_{1}$**H** $_{7}$**N** $_{8}$**O** $_{9}$**F** $_{15}$**P** $_{16}$**S**

MCQ2 Solutions

	A	B	C	D	E
1	X			X	X
2		X			X
3	X		X	X	
4			X		
5					X
6				X	
7	X				
8			X	X	
9					X
10		X			
11			X		
12	X			X	X
13		X			X
14	X		X		X
15				X	
16		X			X
17			X		
18		X		X	
19	X		X		X
20		X		X	X
21			X		
22	X		X		X
23		X		X	
24	X				X
25		X	X		
26				X	
27			X		X

MCQ3

1- Let the following elements be:

${}^{65}_{29}Cu^{+}$, ${}^{36}_{18}Ar$, ${}^{64}_{30}Zn$, ${}^{36}_{16}S^{2-}$, ${}^{66}_{30}Zn^{2+}$

(a) (b) (c) (d) (e)

A) (c - e) have the same number of protons

B) (a – e) have the same number of electrons

C) (a – e) have the same number of neutrons

D) (d – b) have the same number of protons

2- In 0,1 mole of $Ca_3(PO_4)_2$ there is:(Ca : 40 g ; P : 31 g ; O : 16 g)

A) 4.818 10^{23} oxygen atoms

B) 1.204 10^{23} molecules of $Ca_3(PO_4)_2$

C) 6.023 10^{22} calcium atoms

D) 31 g of $Ca_3(PO_4)_2$

3- A) The homogeneous mixture is composed of identical molecules

B) The flaw of Thomson's atom is the absence of the nucleus

C) Bohr's 3rd postulate allows us to calculate the speed of the electron on an orbit

D) The relation Ra = 10^4 Rn indicates that matter is lacunar.

4-A) The chemical element exists in nature as a mixture of isotopes.

B) Isotones represent the same element with the same number of neutrons..

C)) Isobars represent different elements with the same mass number.

D) Isotopes have the same number of protons and the same number of neutrons.

5 - The X nucleus has a binding energy per nucleon equal to: 6.92 MeV/nucleon, a mass defect equal to: 0.08182 amu, and an experimental mass of 11.00656 amu.

We are given mp = 1.007278 amu and mn =1.008665 amu.

A) The mass number is 14 and the atomic number is 7

B) The mass number is 11 and the atomic number is 5

C) The mass number is 14 and the atomic number is 9

D) The mass number is 11 and the atomic number is 4.

6 - Let us consider the electron of hydrogen in orbit 4, with an electron mass of 9.1×10^{-31} kg

A) The radius of the orbit is 8.48 Å

B) The energy of the orbit is 0.85 eV

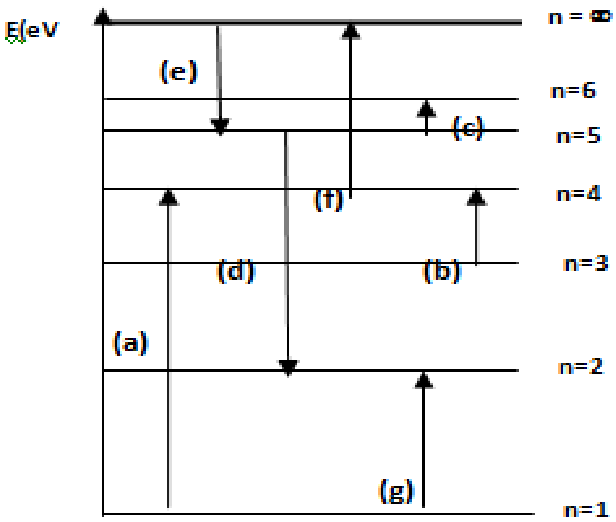
C) The ionization energy from this orbit is: - 0.85 eV

D) This orbit corresponds to the 3rd excited state.

7- The protons in the nucleus do not repel each other because of:

A) kinetic energy **B)** potential energy **C)** cohesive energy **D)** ionization energy

8 – 9 Let the transitions be as shown in the following energy diagram: (Rh = $1.1\ 10^{7}\ m^{-1}$)



8- A) (d) is the fourth Balmer emission line

B) $\Delta E(b) = 1.056\ 10^{-19}$ Joules

C) (f) is the ionization line of the Brackett series

D) (e) is Pfund's last emission line.

9- A) λ (d) = 4329A°

B) (e - c) are in the far infrared range

C) (g) corresponds to the longest wavelength produced in the Lyman series

D) The wave number υ (a)= $1.03\ 10^{5}\ m^{-1}$

10- The wavelength associated with an electron is 6.61 Å, and the speed (m/s) of the e^- will be : **A)** $2.30\ 10^6$ **B)** $3.31\ 10^6$ **C)** $3.13\ 10^6$ **D)** $1.10\ 10^6$

11- Let **: a** ($_3Li^+$) **b**($_4Be^{3+}$) **c**($_5B^{3+}$) **d**($_3Li^{2+}$) **e**($_2He^{2+}$) **f**($_5B^{2+}$) **g**($_5Be^{4+}$) , Hydrogenoids are:

A) (a-d-e) **B)** (b – d – g) **C)**(c – e - f) **D)** (a – f – e)

12- Given the values of the following quantum numbers, indicate which ones are impossible..

a) n =2 l = 1 m = 0 S = + 3/2

b) n =3 l = 2 m = 0 S= +1/2

c) n =3 l = 3 m = -2 S = +1/2

d) n =4 l = 1 m = - 4 S = +1/2

e) n =4 l = 1 m = -1 S = +1/2

A) (a-d- e) **B)** (a - b – c) **C)** (c - e- d) **D)** (a - c - d)

13- Let's take element **$_{29}$Cu,** The number of electrons characterized by quantum number m = +1 is: **A)** 6 **B)** 14 **C)** 8 **D)** 10

14 – 17 Let the elements be: $_{28}$Ni ; $_{23}$V ; $_{51}$Sb ; $_{38}$Sr

14- A) In the periodic table, elements are classified according to their atomic weight.

B) Sr is an alkaline earth metal

C) All elements are paramagnetic.

D) Ni is bivalent

15- A) Ni belongs to the triad

B) V and Sr have the same valence shell

C) V and Sb have the same number of valence electrons

D) Sb belongs to the nitrogen family ($_7$N)

16- A) In the periodic table, the atomic number varies as the metallic character varies.

B) the radius: ra(V)>ra(Ni)

C) Electronegativity: En(Sr)>En(Sb)

D) Sb is a metalloid.

17- A) (V^{2+}) is more stable than (V^{5+})

B) the elements in block f are the transuranic elements

C) (Sb**)** have 46 core electrons

D) The element lanthanum belongs to block f.

18- X^{3+} has the structure of $_{49}In$:

A) Z(X)= 46

B) X belongs to the family VIA

C) X^{2-} is the stable ion of X .

D) X is a metal.

19- If 63% of the H-X bond is polarized covalent and the bond length is 0.72A° (1Debye = 0.33 10^{-29}):

A) the partial ionic character of the bond will be 37%

B) partial charge (δ) will be 2.95 10^{-20} coulombs

C) The dipole moment will be 1.29 Debyes

D) No answer is true

20) Let the ion **N**O_3^- ($_7N$; $_8O$) :

A) the molecule is axial

B) Nitrogen forms three σ bonds and one π bond.

C) the three oxygen atoms are surrounded by two non-bonding doublets

D) It is an AX_3.

21- Let us consider the molecule H**Cl**O_3 ($_1H$; $_{17}Cl$) **:**

A) The bond H-Cl is a σ_{sp}

B) There are three dative bonds and one polarised covalent bond.

C) the angle between the bonds is 109°28’

D) It is an $AX_3 E_1$.

MCQ3 Solutions

	A	B	C	D
1	X	X	X	
2	X			X
3		X		X
4	X		X	
5		X		
6	X			X
7			X	
8		X	X	
9	X		X	
10				X
11		X		
12				X
13	X			
14		X		X
15	X		X	X
16		X		X
17			X	X
18		X	X	
19	X		X	
20		X		X
21	X	X	X	

MCQ4

1- Among the following samples, which one contains 2 10 ^{23} atoms ?

A) 8g of O_2 **B)** 12g of He **C)** 8g of C **D)** 3g of Be **E)** 30g of F_2

(***Data :*** O : 16 ; Be : 9 ; C : 12 ; He : 4 ; F : 19).

2- Among the following representations, which ones characterize isotopes?

1) 20 protons and 20 neutrons

2) 21 protons and l9 neutrons

3) 18 protons and 22 neutrons

4) 20 protons and 22 neutrons

5) 21 protons and 20 neutrons

A: (l, 2,3) **B :** (l, 4) et (2, 5) **C : (**1, 5) **D : (**3, 4) **E : (**3, 4) et **(**1, 5)

3-

A) The protons in the nucleus do not repel each other because of kinetic energy..

B) The relationship $Rn = 10^{-4} Ra$ indicates that the material is incomplete and H_2 is a simple pure substance.

C) Water-sugar homogeneous mixture and ozone O_3 is a pure compound.

D) Rutherford's atomic model is applicable to hydrogenic species

E) Isobars have the same mass number and isotones have the same number of neutrons.

4-

A) The mass of a molecule of C_2H_5OH (H= 1, C = 12, O = 16) is equal to 46 amu.

B) The mass of a molecule of C_2H_5OH is 7,63 10^{-24} g.

C) In 60g de C_2H_5OH we find : 1.304 mole of C_2H_5OH and 7.853 10^{23} molecules of C_2H_5OH.

D) $^{59}_{29}Co$ has 29 protons and 32 neutrons et $^{27}_{13}Al^{3+}$ has 13 protons and 13 électrons.

E) amu is 1 / 12th of the mass of a carbon 13, and CO_2 is a pure compound.

5-6 Let the nucleus of uranium: $^{235}_{92}U$

Given: mp = 1.007278 amu, mn = 1.008665 amu , M exp de U = 234.9942 amu a (Xe) = 8.06 MeV/nucleons

5-

A) The radius of the U nucleus is 7,827 10^{-5} A°

B) The theoretical mass of the nucleus is 236.9086 amu.

C) The theoretical mass of the U nucleus is 235.3045 amu.

D) The radius is 8.727 10^{-5} A°

E) The mass defect is the mass gained during the formation of the nucleus

6-

A) Xe is the most stable nucleus

B) The mass defect of U is 0.9144 amu

C) The binding energy of U is 1782.3064 MeV

D) The binding energy stabilizes the nucleus

E) The cohesion energy destabilizes the nucleus.

7- . Let's consider an electron of the hydrogen atom in the 5th excited state:

A) The radius of the orbit is: 18.09 A°

B) The energy of the orbit is: - 0.37 eV

C) The ionization energy from this orbit is: 0.554 eV

D) To transition from this orbit to the Balmer ground state, an energy of -3.03 eV is required.

E) The lines of the Pfund series are found in the far IR**.**

8- To ionize the element $_3Li^{2+}$ from orbit 4, we need radiation with a frequency ν that is : (h = 6.62 10^{-34} J s^{-1})

A) 1.848 10^{15} s^{-1} **B)** 18. 48 10^{-14} s^{-1} **C)** 1.484 $10^{16}s^{-1}$ **D)** 14. 84 10^{-16} s^{-1} **E)** 1.848 10^{14} s^{-1}

9- The transition of an electron in a hydrogen atom from the ground state to the excited state requires 12.084 eV. How much energy (in kJ) will be required for the transition of one mole of electrons?

A) 728 kJ **B)** 984.2 kJ **C)** 1036 kJ **D)** 1164.51 kJ **E)** 1312.7 kJ

10- Among the following combinations of quantum number values, indicate those that are impossible :

1) $n = 2$; $\ell = 1$; $m = -1$; $s = +3/2$ 2) $n = 3$; $\ell = 2$; $m = 0$; $s = +1/2$

3) $n = 3$; $\ell = 3$; $m = -2$; $s = -1/2$ 4) $n = 4$; $\ell = 3$; $m = -3$; $s = + 1/2$

5) $n = 4$; $\ell = -1$; $m = - 1$; $s = + 1/2$

A) (1, 3) **B)** (3, 4, 5) **C)** (2, 4) **D)** (3, 5) **E) (**1, 2, 5)

11- In an atom, what is the maximum number of electrons that can be characterized by the quantum state $n = 4$, $m = 1$ and $s = + 1/2$.

A) 6 **B)** 3 **C)** 2 **D)** 4 **E)** 5

12-

A) For an electron in the d subshell, m can have the value 3

B) An electron characterized by the quantum state ($n = 4$, $\ell = 3$, $m = -1$, $s = +1/2$) is located on the N shell and in the $4f_{-1}$

C) If $n = 3$, m can be equal to -2

D) Helium and arsenic are semiconductors

E) Element t $_{93}Np$ is a transuranic element

13- The atomic number (Z) of atoms that have less than 10 electrons and possess a single unpaired electron in the ground state is:

A) 1, 3, 5, 9 **B)** 1, 5, 7, 9 **C)** 1, 3, 5, 7 **D)** 1, 3, 7, 9 **E)** NAT **(**No answer is true**)**

14- A) Halogens are electropositive.

B) The elements of the f-block are the inner transition elements

C) The alkaline earth metals give divalent cations.

D) The elements with $Z \geq 89$ are the lanthanides

E) The elements of the triad possess similar chemical properties.

15-16 Let the following elements be

X: (Ar) $4s^2 3d^{10} 4p^4$ Y: (Kr) $5s^2 4d^{10} 5p^1$ $_{31}$Ga and $_{42}$Mo

15-

A) X and Mo belong to the same family.

B) Y and Ga have the same number of valence electrons

C) Y and Mo have the same number of core electrons

D) Y and Ga are monovalent

E) Y and Mo have the same valence shell and 4d is their inner valence subshell.

16- A) The atomic radius ra(Y) > ra (Ga)

B) Ga is a post-transition metal and Mo is an outer transition metal

C) X^{-2} and Mo^{+} are stable ions.

D) The most electronegative element is Y and Mo has the greatest metallic character.

E) All the elements are diamagnetic.

17-18 The dipole moment of the HCl bond is equal to 5.88 Debyes, its ionic percentage is 77%. We are given: 1 Debyes = 0.33 10^{-29}coulombs meters

17 - The partial charge (coulombs) is:

A) 1. 20 10^{-20} **B)** 1.83 10^{-21} **C)** 1.68 10^{-21} **D)** 1.23 10^{-19} **E)** 1.20 10^{-19}

18- The length of the bond (A°) is :

A) 1.77 **B)** 1.57 **C)** 1.47 **D)** 1.86 **E)** 1. 67

19- A) The ozone molecule O_3 is of the AX_2E_1 type.

B) The **S**O_4^{-2} ion is planar.

C) There is at least one dative bond in SO_4^{-2}

D The Li H bond is an $\sigma_{s\text{-}p}$ bond.

E) H_2**O** and HCl**O** have the same geometry.

Given : $_1$H $_3$Li $_8$O $_{16}$S $_{17}$Cl)

MCQ4 Solutions

	A	B	C	D	E
1				X	
2		X			
3		X			X
4	X		X		
5		X		X	
6	X		X	X	
7		X		X	X
8	X				
9				X	
10	X			X	
11		X			
12		X	X		X
13	X				
14		X	X		X
15		X		X	X
16	X	X	X		
17				X	
18		X			
19	X		X		X

MCQ5

1) Let us consider the compounds listed in the following table:

a	b	c	d	e	f	g	h	i	j
$^{14}_{6}C$	NaOH Solution	$^{14}_{7}N$	water	Sea water	CO_2	$^{12}_{5}B$	Zn	Mineral water	water + Petrol

A) (a-c) isobars and (c-g) isotops

B) (d-e-i) homogeneous mixtures

C) (a-c-g-h) simple pure substances

D) (d-f) pure compound substances

E) No answer is true.

2) $1.24\ 10^{22}$ molecules of $FeSO_4$ correspond to : (Fe : 56 S : 32 O : 16)

A) $1.24\ 10^{22}$ sulphur atoms

B) 2.129 g of $FeSO_4$

C) 0.02 moles of $FeSO_4$

D) $4.96\ 10^{23}$ oxygen atoms.

E) No answer is true.

3) Let X be the nucleus, the mass of protons is 4.029112 amu, the mass of neutrons is 5.043325 amu, and the actual mass is 9.04508 amu..

We give: mp =1.007278 amu ; mn = 1.008665 amu.

A) The mass defect is 0.027357 amu

B) The binding energy is 28.469 MeV

C) The binding energy is $4.087\ 10^{-12}$ joules

D) The binding energy per nucleon is: 2.82 MeV/nucléons

E) The radius of the nucleus is: $4.94\ 10^{-15}$m.

4 – 5 The electron of the hydrogen atom in the 6th excited state returns to the Balmer ground state.

. (Mass of e^- : $9.1\ 10^{-31}$Kg)

4)

A) The energy corresponding to this transition is: - 13.122 eV

B) The wavelength of the line of this transition is: 3959 A°.

C) This line is in UV

D) The speed of the electron in the 6^{th} excited state is: $3.122\ 10^5$ m/s

E) None of the answers are true.

5)

A) The frequency of this line is : $2.51\ 10^6\ s^{-1}$

B) The wavenumber is: $7.54\ 10^{14}\ m^{-1}$

C) The ionization energy from the 6^{th} excited state is : 0.277 eV

D) The radius of the 6^{th} excited state is 25.97 A°

E) None of the answers are true.

6)

A) The hydrogenoid is an ion

B) There are 4 postulates of Bohr

C) De Broglie's relation is : $\lambda = h / mv$

D) Bohr's theory is valid for all atoms

E) the electrons of the same atomic orbital have the same quantum numbers

7) How many electrons are characterized by the following quantum numbers:

(**a**) n= 4 l = 3 (**b**) n =3 (**c**) n =4 m = 0 (**d**) n = 4 s = + 1/2

A) a (14 e-) **B)** b (8 e-) **C)** c (10 e-) **D)** d (16 e-) **E)** None of the answers are true.

8) Among the following compounds, which ones are paramagnetic?

A) $_{12}Mg^{2+}$ **B)** $_{17}Cl^-$ **C)** $_3Li^{2+}$ **D)** $_{19}K$ **E)** None of the answers are true

9 – 11 Let the elements: $_{39}Y$ $_{46}Pd$ $_{51}Sb$

9)

A) $_{51}$ Sb is an alkali and $_{46}$ Pd belongs to the triads

B) Ei (Sb) > Ei (Pd)

C) Pd has one inner valence sublayer and two outer valence sublayers

D) Y and Pd are transitional elements

E) None of the answers are true.

10)

A) Pd is bivalent and Sb has 46 core electrons.

B) Sb can form Sb^{3+} and Sb^{5+} ions.

C) In the Y series, the lowest energy valence sublayer is 5s and Y is monovalent.

D) ra (Pd) > ra (Y)

E) None of the answers are true.

11)

A) Sb belongs to IVA

B) Pd belongs to VIIIB

C) Y belongs to IIA

D) Sb is a semiconductor

E) None of the answers are true.

12)

A) The radius of the cation is greater than the radius of the atom.

B) Alkali metals are called semiconductors.

C) Metallic character increases from top to bottom in a column.

D) The elements in the f block are the inner transition metals.

E) The actinides correspond to the filling of the 5f orbital and the lanthanides to the filling of the 4f orbital.

13 – 15 Let the ions be: **C**O_3^{2-} **N**O_2^{-} H**P**O_4^{2-} [$_1H$;$_6C$;$_7N$;$_8O$;$_{15}P$]

13) For the ion CO_3^{2-} :

A) C (sp^2) and the three oxygen atoms (sp^3)

B) the molecule is spatial.

C) AX_3

D) There is a dative connection.

E) None of the answers are true.

14) For the ion NO_2^{-} :

A) the molecule is flat

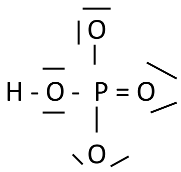
B) nitrogen makes 3(σ) and 1 (π)

C) The ion NO_3^{-} exists

D) AX_2E

E) None of the answers are true.

15) H**P**O_4^{2-} : **A)** Lewis is:



B) flat molecule

C) AX_4

D) phosphorus (P) makes 3(σ) and a dative connection

E) None of the answers are true.

16)

A) the metallic bond is delocalised

B) the covalent bond is stronger than the metallic bond

C) conjugation destabilises the molecules

D) the dipole moment is oriented from the (+) pole towards the (-) pole

E) If the % CI (HCl) = 35%, then 65% of the bond is ionic.

MCQ5 Solutions

	A	B	C	D	E
1			X	X	
2	X		X	X	
3	X		X	X	
4		X		X	
5			X	X	
6	X		X		
7	X			X	
8			X	X	
9		X	X	X	
10	X	X	X		
11		X		X	
12			X	X	
13			X		
14	X		X	X	
15			X	X	
16	X	X		X	
17		X		X	
18	X		X		
19	X		X	X	
20	X		X		
21		X			
22	X			X	

MCQ

General Chemistry
&
Organic Chemistry

MCQ (a)

NAT (None answer is true)

1- Consider the atom $^{63}_{27}Co$ From the following statements, select the correct one(s):

a. This atom consists of 27 neutrons, 36 protons, 36 electrons.

b. This atom is made up of 63 nucleons, 27 protons, 27 electrons.

c. This atom is made up of 27 neutrons, 63 nucleons, 36 electrons.

d. This atom is made up of 36 neutrons, 63 nucleons, 27 protons.

2- What is / are the possible serie / s of quantum number values?

a. n = 2 l = 0 m = 0 **b**. n = 2 l = 2 m = 0 **c.** n = 2 l = 1 m = -1

d. n = 3 l = 1 m= -2

3 - Knowing that Z(Fe) = 26, check the correct statement(s) :

a. The Fe^{3+} ion has 6 electrons in its d orbitals.

b. The Fe^{2+} ion has 6 electrons in its d orbitals.

c. The configuration of the Fe^{2+} is [Ar] $3d^5 4s^1$.

d. (NAT)

4-Among the following statements, which ones are true?

a. In a polarized bond between two atoms, the most electronegative element has an excess of negative charge.

b. In the Pauling scale, the most electronegative element is fluorine.

c. The triad corresponds to family VIIIa.

d. Electronegativity characterizes the tendency of an atom to repel electrons.

5- What is / are the correct statement / s regarding the nitrite ion? NO_2

a. The nitrogen atom is sp^2 hybridized.

b. The negative charge is localized on the nitrogen atom.

c. The nitrite ion has a linear geometry.

d. NAT

6- What is the unit of a reaction rate?

a. mol/L .s **b**. s^{-1} **c.** it depends on the partial orders **d**. mol/ L. s^{-1}

7- The decomposition of an antibiotic in water at 20 °C is a first-order reaction. Determine the antibiotic concentration after 3 months, knowing that the half-life and the initial antibiotic concentration are respectively 0.420 months and 6 10^{-3} mol/L.

a. 3. 9 10^{-3} mol/L **b**. 4. 34 10^{-5} mol/L **c.** 5 10^{-3} mol/L **d**. 5. 98 10^{-5} mol/L

8- **a.** Enzymes are the catalysts of life.

b. A catalyst does not undergo a net chemical transformation in the overall balance.

c. A catalyst increases the kinetic energy of the reactants. **d**. NAT.

9- Which of the following statements is/are correct?

a. An isolated system transfers neither matter nor energy with the outside.

b. A state function is independent of the path taken between the initial state and the final state.

c. A reaction with a positive enthalpy change ($\Delta Hr > 0$) is classified as exothermic.

d. NAT

10. We consider the reaction of the formation of gaseous ammonia at 298° K :

$$N_2(g) + 3\, H_2(g) \rightleftharpoons 2\, NH_3(g)$$

Data à 298°	$NH_3(g)$	$H_2(g)$	$N_2(g)$
S° (J /K mol)	192. 5	191. 6	130. 7
ΔH_f ° (Kj/:mole)	- 46. 1	-	-

The standard free enthalpy change in kJ/mole à 298° K is:

a. 3.309 **b**. 4.409 **c.** -3.305 **d.** - 4.406

11. Consider the following series of nitrogen compounds: N_2, NO, HNO2 et NO_3^-. Among the following propositions giving respectively the oxidation numbers (or degrees) of nitrogen in these different species, indicate the correct proposition.

a. 0, +II, +III, +IV **b.** +I, +II, +III, +V **c.** 0, +II, +III, +V **d.** NAT

12. a. The algebraic sum of the oxidation numbers (or degrees) of the different elements present in an uncharged chemical species is equal to zero.

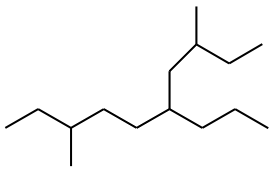
b. The standard hydrogen electrode has a potential equal to zero if :

$p(H_2)$ = 1 atm and $[H_3O^+]$ = 1mole/l

c. Fluorine is the most powerful reducing agent.

d. An oxidation corresponds to a decrease in the oxidation number (or degree).

13. Consider the following molecule:



His name according to the IUPAC is:

a. 3.8-dimethyl-6-propyl Decane

b. 3.8-dimethyl-6-propyl Heptane

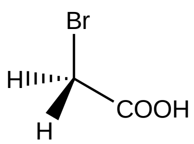
c. 3-methyl-6-butyl Nonane

d. 3.8-dimethyl-5-propyl Decane

14. Let the following compound be : $HOCH_2$-CHOH-CHCl-CHOH-CHO :

a. the name is: 3-chloro-1,2,4-trihydroxy Pentan-6-al
b. it has 4 asymmetric carbons
c. the name is: 3-chloro-2,4,5-trihydroxy Pentanal
d. it has 3 asymmetric carbons

15 – 19 Let the following pairs of molecules be :



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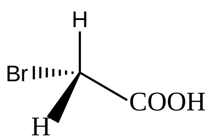

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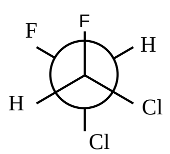

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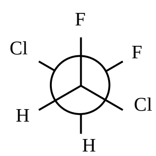

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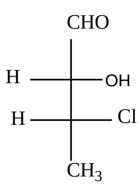

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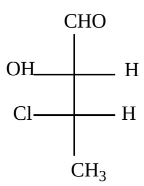

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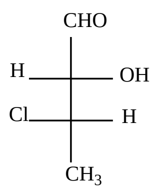

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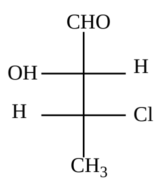

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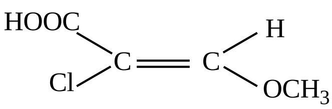
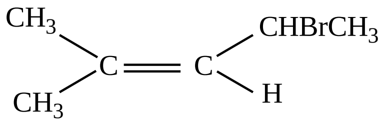




9 **10**

15. a. the configuration of 9 is (Z)

b. the configuration of 10 is (E)

c. the molecule 10 is chiral **d.** NAT

16. **a.** 1-2 are enantiomers

b. 1-2 are diastereomers

c. 1-2 are identical **d.** NAT

17. **a.** 3-4 are identical

b. 3-4 are compliant

c. 3-4 are enantiomers **d.** NAT

18. The configuration of 5 is : **a.** (2S, 3S) **b.** **(**2S, 3R) **c.** (2R, 3R) **d.** (2R, 3S)

19. **a. (**5-6) are diastereomers

b. (7-8) are enantiomers

c. (6-7) are diastereomers

d. (6-8) are identical

20. d'énantiomères a molecule with 3 asymmetric carbons can have:

a. 8 stereo-isomers and 4 pairs of enantiomers

b. 16 stereo-isomers and 8 pairs of enantiomers

c. 32 stereo-isomers and 16 pairs of enantiomers

d. 4 stereo-isomers and 2 pairs of enantiomers.

Data : $_{1}H$ $_{6}C$ $_{7}N$ $_{8}O$ $_{17}Cl$ $_{35}Br$

MCQ (a) Solutions

	A	B	C	D
1		X		X
2	X		X	
3		X		
4	X	X		
5	X			
6			X	
7		X		
8	X	X	X	
9	X	X		
10	X			
11			X	
12	X	X		
13				X
14		X	X	
15	X		X	
16			X	
17		X		
18		X		
19		X	X	
20	X			

MCQ (b)

1 : Among the following photons, which one is likely to cause the transition of an electron from the second excited level to the third excited level of $4Be^{3+}$?

A) 10.5 J **B)** 30 eV **C)** $1.68\ 10^{-18}$ eV **D)** 10.5 eV **E)** 5.95 eV

2 : Give the number of valence electrons of these elements: a) $_{8}O$ b) $_{20}Ca^{+}$ c) $_{56}Ba$

A) 2 -1 - 0 **B)** 6- 2- 2 **C)** 4 -0 -2 **D)** 4 -1 -2 **E)** 6 -1 -2

3 : What is the De Broglie wavelength (in meters) of an electron moving at a speed

of $0.75\ 10^{7}$ m/s ?

Data : m (electron) = $9.1\ 10^{-31}$kg ; Planck constant h = $6.62\ 10^{-34}$ J.s

A) $9.7.10^{-10}$ **B)** $5.5.10^{-10}$ **C)** $9.7.10^{-11}$ **D)** $5.5.10^{-11}$ **E)** None of these propositions is correct.

4 : Which configuration(s) is (are) correct? :

(A)	↑↓	↑	↑	↑
(B)		↑↓	↑↓	↑↓
(C)	↑↓	↑	↑↓	
(D)	↑↓	↑↑	↑	↑

E) None of these propositions is correct.

5 : A) The flaw in Thomson's atomic model is the existence of the vacuum.

B) the energy of the electron on the orbit is constant in Bohr's model.

C) The nucleus with the highest binding energy is the most stable.

(D) The Rutherford model is the planetary model and the flaw in Bohr's theory is that it is limited.

E) None of these statements are correct

6 : A) the element $_{93}Np$ is a transuranic.

B) Non-metals are electropositive

C)) the metallic character varies with the atomic radius in the periodic table.

D) Nitrogen $_7N$ is bivalent

E) Fluorine is the least electronegative element in the periodic table

7: Give the VSEPR family of the atoms in bold in the following molecules:

	1) $H_2\mathbf{O}$	2) $\mathbf{P}F_3$	3) $H\mathbf{Cl}$	4) $\mathbf{C}H_4$
A)	AX_2	AX_3	AX	AX_4
B)	AX_2E_2	AX_3E	AXE_3	AX_4
C)	AX_2	AX_3E_3	AX_3E	AX_4E
D)	AX_2E	AX_3E	AXE_3	AX_4

E) None of these propositions is correct.. ***Data :*** $_1\mathbf{H}$ $_6\mathbf{C}$ $_8\mathbf{O}$ $_9\mathbf{F}$ $_{15}\mathbf{P}$ $_{17}\mathbf{Cl}$

8 – 9 Let the reaction: $C(s) + 2\,H_2O(g) \longrightarrow CO_2(g) + 2\,H_2(g)$ 298°K

$\Delta H°_f[H_2O(g)] = -241.83$ K joule/mole $\Delta H°_f[CO_2(g)] = -394.59$ K joule/mole

8 : A) The reaction is exothermic

B) The internal energy is: 86.59 K joule

C) The enthalpy is: - 89.59 K joule

D) The reaction is endothermic

E) None of these statements is correct.

9 : A) The reaction occurs with an increase in volume

B) The closed system exchanges matter with the external environment

C) In thermal equilibrium there is a change in pressure and volume

D) When a variable changes the system is in equilibrium

E) None of these statements is correct None of these statements is correct None of these statements is correct

10 : We consider the following reaction:

$$Cr_2O_3(s) + 2\,Al\,(l) \rightleftarrows Al_2O_3(s) + 2Cr(s) \qquad \Delta H° = -\ 558 Kjmol^{-1}$$

Among the following statements, which ones are correct:

A) An increase in pressure shifts the equilibrium in direction (1)

B) The reaction is exothermic

C) An increase in temperature shifts the equilibrium in direction (2)

D) The addition of Al(l) shifts the equilibrium in direction (2)

E) None of these statements is correct.

11 : Let's consider the dissociation of the salt calcium fluoride: $CaF_2 \rightleftarrows Ca^{2+} + 2F^-$

If the constant Ks = $3.4\ 10^{-11}$, the solubility of the salt in g/l will be : (Ca = 40 ; F = 19)

A) $1.59\ 10^{-2}$ **B)** $3.59\ 10^{-2}$ **C)** $2.59\ 10^{-2}$ **D)** $1.59\ 10^{-2}$ **E)** $2.59\ 10^{-2}$.

12 : Indicate the correct Nernst relations:

A) (Fe^{2+}/ Fe): $E = E° + 0.\ 06/2 \log [Fe^{2+}] / [Fe]$.

B) (Fe^{3+}/ Fe^{2+}): $E = E° + 0.\ 06\ \log [Fe^{3+}] / [Fe^{2+}]$.

C) (F_2 / F^-):

$E = E° + 0.\ 06/2 \log P_{F2} / [F^-]^2$

D) $Cr_2O_7^{2-}$/ Cr^{3+}(acidic environment)$^{:}$ $E = E° + 0.\ 06/6 \log [Cr_2O_7^{2-}] / [Cr^{-3+}]$

E) None of these statements is correct

13 : Either the standard potentials of the following pairs :

E° (Zn^{2+}/ Zn) = -0.76 volt. E° (F_2/F^-) = 2.65 volt, E° (Cu^{2+}/Cu) = +0.34 volt and the following balance:

$$Cu^{2+} + Zn \rightleftarrows Zn^{2+} + Cu$$

A) The reaction will occur in direction (1)

B) The reaction will occur in direction (2)

C) The most oxidising element is F_2

D) The most reducing element is Cu^{2+}

E) The most reducing element is Zn

14 : Let the following expressions be given:

a) $1 / [A] - 1/ [A]_0 = kt$ **b)** $t_{1/2} = Ln2 /k$ **c)** $Ln [A] / [A]_0 = - kt$

d) $t_{1/2} = [A]_0 / 2k$ **e)** $[A] - [A]_0 = - kt$ **f)** $t_{1/2} = 1 / k [A]_0$.

Indicate the expressions that indicate that the reaction is of order 2.

A : (a- f- e) **B:** (a - f) **C:** (b - e - d) **D:** (c - d) **E:** (e - f)

15 : Compounds with the formula CnH_2n are :

A cyclic alkanes

B) alkynes

C) alkenes

D) cyclic alkenes

E) aromatic compounds

16 : Consider the molecule:: $HOCH_2$- CHOH- CHCl -CHOH –CHO. The name is :

A) 4-chloro-3, 5, 6-trihydroxyhexanal

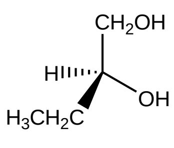
B) 3-chloro-1, 2, 3-trihydroxypentanol

C) 3-chloro-2, 4, 5-trihydroxypentanal

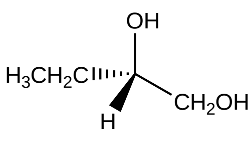
D) 3-chloro-1, 2, 4-trihydroxypentanal

E) None of these suggestions are correct

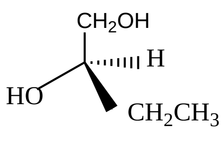
17 – 19 Let us consider the following molecules:



(a)



(b)



(c)

17 : A) (a-b) enantiomers

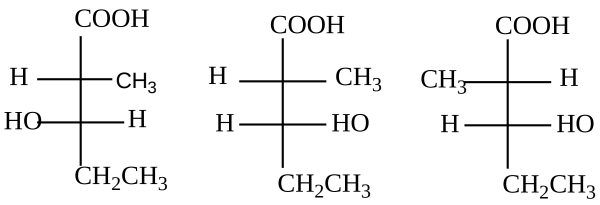
B) (b-c) diastereoisomers

C) (a-b) identical

D) (a-c) enantiomers

E) configuration of (c) is R.

18- 19 Let us consider the following molecules :



(a) **(b)** **(c)**

18 :

A) (a-c) enantiomers

B) (b-c) enantiomers

C) (a-b) diastereoisomers

D) (a-b) identical

E) (a-c) conformers

19 : The configuration of **(a)** is :

A) 2S, 3S

B) 2R, 3S

C) 2R, 3R

D) 2S, 3R

E) None of these proposals is correct.

20 :

A) Diastereoisomers are mirror images of each other.

B) A molecule with four asymmetric carbons and no symmetry will have 16 stereoisomers.

C) Enantiomers have different optical rotations.

D) Racemic compounds are optically active

E) None of these proposals is correct.

Data : $_{1}H$ $_{6}C$ $_{8}O$

MCQ(b) Solutions

	A	B	C	D	E
1				X	
2					X
3			X		
4	X				
5		X		X	
6	X		X		
7		X			
8		X		X	
9	X		X		
10		X	X		
11	X				
12		X	X		
13	X		X		X
14		X			
15	X		X		
16			X		
17			X	X	X
18	X		X		
19		X			
20		X	X		

MCQ(c)

1 Given that Z(Fe) = 26:

A. The Fe^{3+} has 6 electrons in its d orbitals.

B. The Fe^{2+} has 6 electrons in its d orbitals.

C. The configuration of the Fe^{2+} ion is [Ar] $3d^5\ 4s^1$.

D. The configuration of the Fe^{3+} ion is [Ar] $3d^5\ 4s^0$.

2 What is/are the possible series of quantum number values?

A. n = 2 l = 0 m = 0

B. n = 0 l = 0 m = 0

C. n = 2 l = 1 m = −1

D. n = 3 l = 1 m = −2

3- For a hydrogen atom, the radius of an orbit is equal to 25.97 A°. This is the orbit :
A. 7 **B.** 8 **C.** 6 **D.** 5

4- The wavelength associated with an electron is 6.61 A°. The speed of the e^- (m/s) will be :
A. $2.30\ 10^6$ **B.** $3.31\ 10^6$ **C.** $1.10\ 10^6$ **D**. $3.20\ 10^6$

5- Which of the following compounds are paramagnetic ?

A. $_{12}Mg^{2+}$ **B.** $_{17}Cl^{-}$ **C.** $_{3}Li^{2+}$ **D.** $_{19}K$

6- For $_{55}Cs$: **A.** family Ia **B.** bivalent **C.** electropositive **D.** valence shell: 5

7- For **B**F_3 :

A. Single covalent bonds

B- Equilateral triangle

C. Respects the octet rule

D. AX_3E. **($_5$B ; $_9$F)**

8 – 12 Let us consider the following equilibrium: C_2H_4 (g) + H_2O (g) $\rightleftharpoons$ C_2H_5OH (g)

	ΔH°f (Kj/mole)	ΔG°f (Kj/mole)
C_2H_4	52.28	68.12
H_2O	-241.83	-228.59
C_2H_5OH	-235.08	-168.45

8- Standard free enthalpy (Kj) is : **A.** – 9.87 **B.** + 7.98 **C.** + 9.87 **D.** -7.98

9- A. The reaction is possible at 25°C

B. The reaction is exothermic at 25°C

C. The reaction is spontaneous at 25°C

D. Disorder increases.

10- The equilibrium constant Kp at 25° is : **A.** 25.089 **B.** 52.023 **C.** 43. 12 **D.** 34.21

11- The equilibrium constant Kc at 25° is: **A.** 361.02 **B.** 136.1 **C.** 613.07 **D.** 631.08

12- A. If the temperature increases, the equilibrium shifts in direction (1).

B. If a quantity of H_2O is removed, the equilibrium shifts in direction (2).

C. If the pressure decreases, the equilibrium shifts in direction (2) decreases.

D. If the temperature decreases, the formation of H_2O is favoured.

13- A. Van't Off's relationship is : $d \ln Kp/dT = - \Delta H /RT$

B. In an isolated system, the transformation is irreversible when entropy decreases

C. A phase change occurs at constant temperature and heat

D. The absolute entropy of zinc is zero at - 273°

14- A. For an isochoric transformation: internal energy = heat

B. Isobaric transformation $P_1/T_1 = P_2/T_2$

C. For a closed transformation, the enthalpy is not zero

D. Isochoric transformation: $P_1/P_2 = T_1/ T_2$.

15- A. Diastereoisomers are optically active

B. The meso form is found in compounds with at least one asymmetric carbon

C. . An optically inactive molecule is chiral

D. All organics compounds are primarily hydrocarbons

16- Consider the following pairs of molecules:

CH_3-CH_2-CH_2OH et CH_3-O-CH_3 **(a)**

CH_3-CH_2-CH_2OH et CH_3-CHOH-CH_3 **(b)**

CH_2=CH-CH_2-CH $_2CH_2CH_3$ et CH_3-CH=CH- CH (CH_3)- CH_3 **(c)**

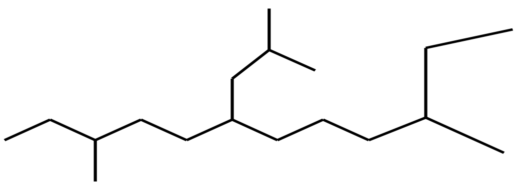
A. (b) and (c) represent positional isomers.

B. (b) represents chain isomers.

C. (a represents functional isomers.

D. (c) represents chain and positional isomers.

17- Consider the molecule



The name of the molecule is :

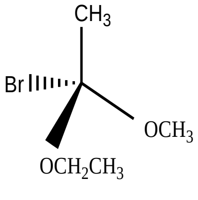
A. 7-isobutyl-3,10-dimethyl Dodecane

B. 6-isobutyl-3,10-dimethyl Dodecane

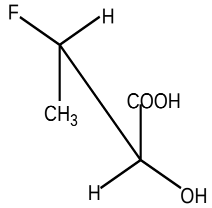
C. 10-ethyl-6-isobutyl -3-methyl Undecane

D. 2-ethyl-6-isobutyl-9-methyl Undecane.

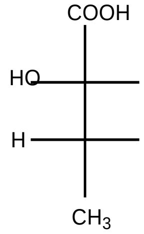
18 – 20 Let us consider the following molecules: ($_1$H $_6$C $_8$O $_9$F)



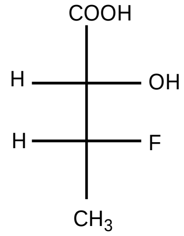
(a)



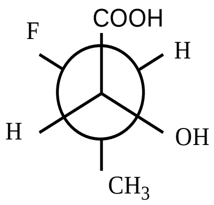
(b)



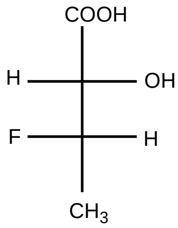
(c)



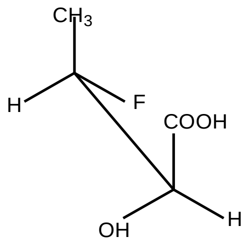
(d)



(e)



(f)



(g)

18) A. The configuration of (a) is R

B. The configuration of (a) is S

C. Molecule (e) is more stable than (g)

D. Molecule (e) is the Newman structure of (b).

19) A. (c-d) are enantiomers

B. (f-d) are diastereomers

C. (b-g) are conformers

D. (d-f) are diastereomers.

20) A. (d) is the Fisher isomer of (b)

B. (c-d-e) are isomers

C. (b-g) are conformers

D. (e) is the Newman isomer of (c).

MCQ (c) Solutions

	A	B	C	D
1	X			X
2	X		X	
3	X			
4			X	
5			X	X
6	X		X	X
7		X		
8				X
9		X	X	
10	X			
11			X	
12		X	X	
13			X	X
14	X			X
15	X			X
16	X		X	X
17		X		
18	X			X
19		X	X	X
20	X		X	

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