Exam Answer

Exercise 1

a- Complete the reaction :

$$^{12}_{6}C + \ ^{2}_{1}H \longrightarrow \ ^{13}_{7}N + \ ^{1}_{0}n$$

0,5

- Nature of the reaction**:** **Nuclear transmutation** 0,5

b- The energy released during this reaction in **Joules** and **MeV**.

$\Delta m = \sum m(products) - \sum m(reactants)$ 0,25

$\Delta m = [m(^{13}N) + m(n)] - [m(^{12}C) + m(d)]$

$\Delta m = (13.0057 + 1.0087) - (12.0107 + 2.0141) = 14.0144 - 14.0248$

$\Delta m = -0.0104$ amu 0,5

E in Joules (J):

$E = \Delta m \cdot C^2 = (-0.0104 \times 1.66 \times 10^{-27}\ kg) \times (3 \times 10^8)^2$ 0,25

0,25

$E = -1.5537 \times 10^{-12}\ J$ 0,5

E in MeV: $E = \Delta m \times 931.5 = -0.0104 \times 931.5$

0,25

$= -9.6876$ MeV 0,5

2- The relative abundance of the two isotopes:

$X_1 + X_2 = 100 \rightarrow X_2 = 100 - X_1$ 0,25

$\overline{M} = [\ (M_1 \cdot X_1) + (M_2 \cdot X_2)\ ] / 100$ 0,25

$39.0983 = [38.9637 . X_1 + 40.9618 . (100 - X_1)\ ] / 100$ 0,25

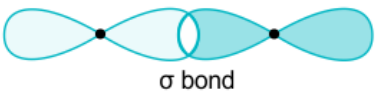
Abundance of ^{39}K: $X_1 = 93.26\%$ 0,5

Abundance of ^{41}K: $X_2 = 100 - 93.26 = 6.74\%$ 0, 5

Exercise 2

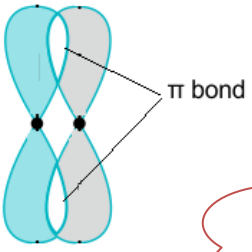
1- The difference between sigma (σ) and pi (π) bonds:

0, 5



0,25

Axial overlap



0, 5

0,25

Lateral overlap

2- The type of chemical bonds:

0,25

KCl : . Ionic bond.

HCl : Polar covalent bond.

0, 25

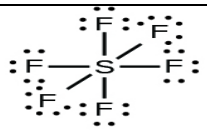
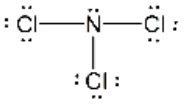
0,2 5

Cl_2 : Non-polar covalent bond

0, 25

H_2O: Polar covalent bond

3- Complete the following table :

Compound	Lewis structure	AXnEp (VSEPR theory)	Geometry	Hybridization of the central atom
$\underline{S}F_6$		AX_6	Octahedral	sp^3d^2
$\underline{N}\ Cl_3$		AX_3E_1	Trigonal Pyramidal	sp^3

0, 5× 2

0,25× 6

Exercise 3

1-

Element	Electronic configuration	Period	Group and sub-group	family
$_{19}K$	[Ar] $4s^1$	4	IA	Alkali Metal
$_{40}Zr$	[Kr] $5s^2\ 4d^2$	5	IVB	Transition Metal
$_{49}In$	[Kr] $5s^2 4d^{10}\ 5p^1$	5	IIIA	Trivalent metal

0, 5× 3

0,25× 9

2- The most stable ions:

0, 25

$_{19}K$: The most stable ion is **K^+**.

- *Justification:* It loses 1 electron to achieve the noble gas configuration.

0,25

$_{49}In$: The most stable ion is **In^{3+}**.

0, 25

- *Justification:* It loses 3 electrons to achieve a stable noble gas configuration.

0,25

3- The atomic numbers of **X** and **Y** 0,25

X: Same period as K (n=4), Same group as Zr (valence shell: $4s^2\,3d^2$

Configuration: $_{22}\mathbf{X}$: $[_{18}Ar]\ 4s^2 3d^2$ 0, 5

Y: Quantum numbers: n=4,ℓ=1,mℓ=−1,ms=+1/2. ⟹ The $(4p^1)$ subshell 0,25

Configuration: : $_{31}\mathbf{Y}$: $[_{18}Ar]\ 4s^2 3d^{10} 4p^1$ 0, 5

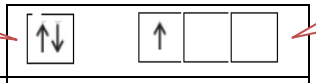
4- 0, 5

$_{40}\mathbf{Zr}$ and $_{22}\mathbf{X}$ are transition metals.

Justification: Belongs to **d-block** and **d** orbitals are not fully filled (d^{10}) 0,25

5- The quantum numbers (n,ℓ,m_ℓ,ms) characterizing the valence electrons($\mathbf{5s^2\,5p^1}$) of element $_{49}$In.

0, 75 0, 5



n	5	
ℓ	0	1
m_ℓ	0	-1
ms	+1/2 -1/2	+1/2

6- Classify these elements (K ; In ; X; Y) in increasing order of atomic radius and ionization energy.

In the same period: $\boldsymbol{Z} \nearrow \Longrightarrow \boldsymbol{Ei} \nearrow, \boldsymbol{r}\text{i} \searrow$ 0, 25

$\boldsymbol{r}\ (_{23}Y) < \boldsymbol{r}\ (_{22}X) < \boldsymbol{r}\ (_{19}K)$ 0, 5

$\boldsymbol{Ei}\ (_{19}K) < \boldsymbol{Ei}\ (_{22}X) < \boldsymbol{Ei}\ (_{23}Y)$

In the same group: $\boldsymbol{Z} \nearrow \Longrightarrow \boldsymbol{Ei} \searrow, \boldsymbol{r}\text{i} \nearrow$ 0,2 5

$\boldsymbol{r}\ (_{23}Y) < \boldsymbol{r}\ (_{49}In)$ 0, 5

$\boldsymbol{Ei}\ (_{49}In) < \boldsymbol{Ei}\ (_{23}Y)$