| | مسابقة في مادّة الكيمياء | الاسم: |
| | المدّة: ساعة واحدة | الرّقم: |

This Exam Is Composed of Three Exercises. It Is Inscribed on Two Pages, Numbered 1 and 2. Answer the Following Three Exercises:

Exercise 1 (7 points) **Calcium Fluoride**

Calcium fluoride is an ionic compound of formula CaF_2. It is a white solid used to manufacture optical components such as lenses and telescopes. Nano-sized calcium fluoride is an effective agent against tooth decay.

Document-1 is a diagram that shows the transfer of electrons from calcium (Ca) atom to fluorine (F) atoms during the formation of calcium fluoride.
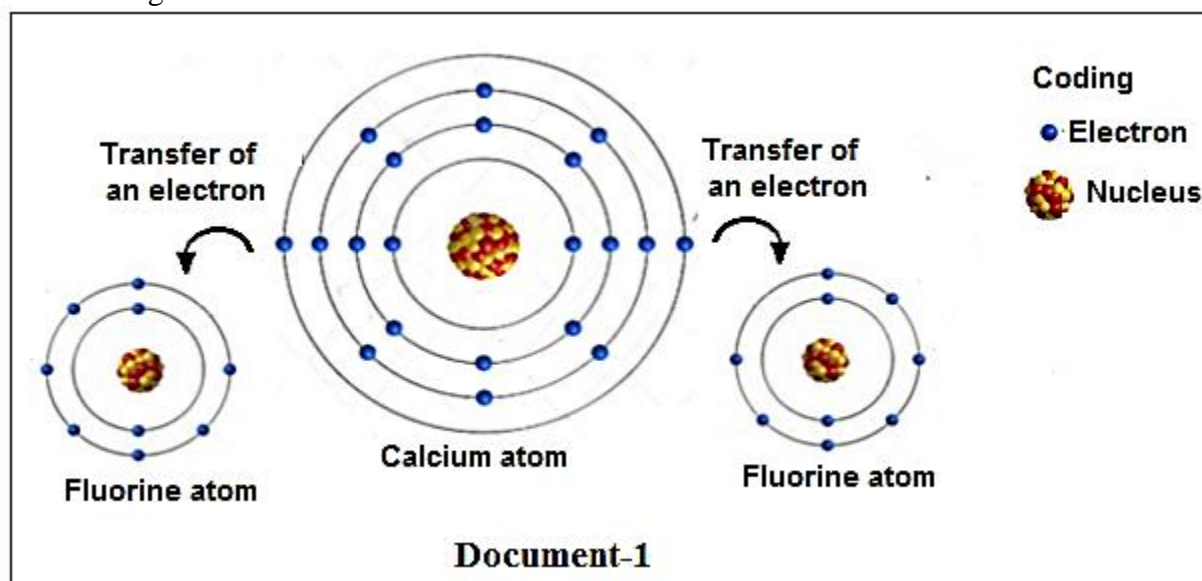
Document-1

1- Pick out from the text:
    1.1- The use of calcium fluoride.
    1.2- The importance of nano-sized calcium fluoride.
2- Referring to **Document-1**, answer the following questions:
    2.1- Show that the atomic number of calcium element is 20.
    2.2- Specify the valence of fluorine element.
    2.3- Identify the type of bond in calcium fluoride.
3- The relative charge of the nucleus of the calcium atom is equal to 20+
    - Deduce the relative charge of the nucleus of the calcium ion.
4- Fluorine element has many isotopes. Only one of them is stable and naturally occuring. The representation of this isotope is $^{19}_9F$.
    - Justify the following statements:
    4.1- The nucleus of the stable isotope of fluorine contains 10 neutrons.
    4.2- Isotopes of the same element have the same electron configuration.

Exercise 2 (6 points)   Hydrogen Chloride

Hydrogen chloride (HCl) is a colorless gas of strong odor. An aqueous solution of this gas is called hydrochloric acid.

Hydrochloric acid is present in the gastric juice of humans. Excessive secretion of this acid causes gastric ulcers. A marked deficiency of this acid impairs the digestive process and is sometimes the primary cause of deficiency anemia.

Document-1 shows the position of each of hydrogen and chlorine elements in the periodic table.

Element	Column (group)	Row (period)
Hydrogen	1 (I)	1
Chlorine	17 (VII)	3

Document-1

1- Pick out from the text, the consequences of a marked deficiency of hydrochloric acid in the gastric juice.

2- Referring to **Document-1**, answer the following questions:

    2.1- Give the number of valence electrons of hydrogen.

    2.2- Choose, among the following, the electron configuration of chlorine element. Justify.

    a) $K^2 L^7$ b) $K^2 L^{10} M^7$ c) $K^2 L^8 M^7$ d) $K^2 M^8 L^7$

3- Hydrogen chloride (HCl) is a compound constituted of the elements hydrogen (H) and chlorine (Cl).

    - Explain the bond formation in the hydrogen chloride molecule.

4- Hydrogen chloride may be formed by the direct combination of chlorine (Cl_2) gas and hydrogen (H_2) gas. This reaction is represented by equation **(E)**.

$$H_2 \ + \ Cl_2 \ \rightarrow \ 2 \ HCl \ \ \ \ \ \ \ \ \ \ \ (E)$$

    4.1- Show, using oxidation numbers, that the reaction represented by equation **(E)** is an oxidation-reduction (redox) reaction.

    4.2- Identify the oxidant (oxidizing agent) in this reaction.
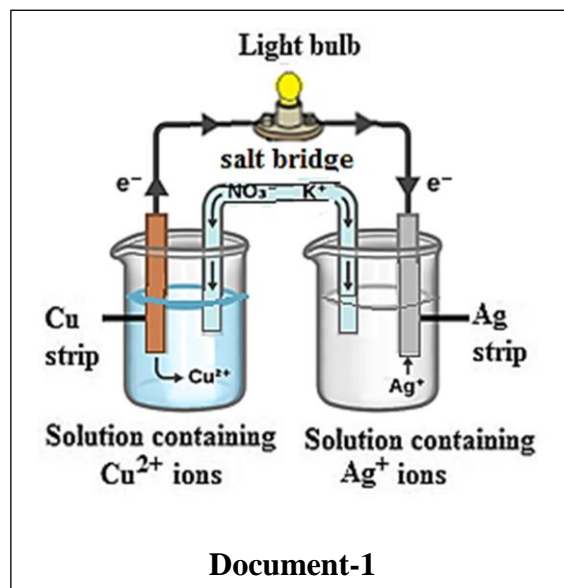
Exercise 3 (7 points)   Electrochemical Cell

An electrochemical cell is a device that converts the chemical energy of a spontaneous redox reaction into electrical energy.
Document-1 shows an electrochemical cell **(G)** constructed with copper (Cu) and silver (Ag) metals.

1- Referring to **Document-1**:

    1.1- Show that copper (Cu) is the anode of the cell **(G)**.

    1.2- Write the schematic representation of this cell.

2- Arrange the metals copper (Cu) and silver (Ag), on an axis according to their increasing tendencies to lose electrons (their reactivity). Justify.

3- Write the oxidation and reduction half-reactions that take place at the electrodes of the cell **(G)**.

4- Deduce the equation of the overall reaction.

5- Justify the following statements:

    5.1- The mass of the copper strip decreases after a certain time of the functioning of the cell **(G)**.

    5.2- The light bulb stops glowing when the salt bridge is removed.

Document-1

Part of the Q	Exercise 1 (7 points) Calcium Fluoride Expected answers	Mark
1.1	Calcium fluoride is used to manufacture optical components such as lenses and telescopes. **(0.5 pt)**.	0.5
1.2	Nano-sized CaF_2 is an effective agent against tooth decay.	0.5
2.1.	Referring to Document-1, calcium atom has 2+8+8+2= 20 electrons **(0.5 pt)** then it has 20 protons (atom is neutral). **(0.25 pt)** Atomic number = number of protons = 20 **(0.25 pt)**	1
2.2.	The valence of fluorine is 1 **(0.5 pt)** Each fluorine atom gains 1 electron from calcium atom to become stable. **(0.5 pt)** (Valence is the number of electrons gained, lost or shared by an atom).	1
2.3	Since there is a transfer of an electron from calcium atom to each fluorine atom **(0.5 pt)**. Then the bond is ionic. **(0.5 pt)**	1
3.	Relative charge of nucleus = number of protons × relative charge of one proton.**(0.25 pt)** Calcium atom and its corresponding ion have the same number of protons **(0.25 pt)** then both have same relative charge of nucleus.**(0.25 pt)** So the relative charge of nucleus of calcium ion = 20+**(0.25 pt)**	1
4.1	The stable isotope of fluorine is $^{19}_{9}F$ The number of neutrons N=A-Z .**(0.5 pt)** = 19 - 9 **(0.5 pt)** = 10	1
4.2	The isotopes of the same element have same atomic number **(0.5 pt)** then they have the same number of electrons **(0.25 pt)** (in a neutral atom, the number of protons is equal to the number of electrons) **(0.25 pt)** therefore they have the same electron configuration.	1

Part of the Q	Exercise 2 (6 points) Hydrogen Chloride Expected Answer	Mark
1.	A deficiency of hydrochloric acid impairs the digestive process and is sometimes the primary cause of deficiency anemia.**(0.25 pt) x 2**	0.5
2.1	Number of valence electrons of H is 1	0.5
2.2	c) $K^2 L^8 M^7$ **(0.5 pt)** Cl belongs to row 3, it has 3 occupied energy levels K L M respectively. **(0.25 pt)** Cl belongs to column 17, it has 7 valence electrons on the energy level M (M^7) **(0.25 pt)** and the previous levels K and L must be saturated by 2 and 8 electrons respectively ($K^2 L^8$). **(0.25 pt)**	1.25
3	- Hydrogen atom has 1 valence electron, it needs 1e⁻ to obey duet rule and become stable. **(0.5 pt)** - Chlorine atom has 7 valence electrons, it needs 1e⁻ to obey octet rule and become stable. **(0.5 pt)**	1.5

	- The two atoms (hydrogen and chlorine) share one pair of electrons forming a single covalent bond. **(0.5 pt)**	
4.1	**$H_2 + Cl_2 \rightarrow 2\ HCl$** $\quad$ 0 $\quad$ 0 $\qquad$ +1 x $\quad$ **(0.25 × 2)** Let x be the oxidation number of Cl in HCl: $1+ x = 0 \Rightarrow x = -1$ **(0.25pt)** - The oxidation number of chlorine element decreases from 0 to −1 (it undergoes reduction).**(0.25 pt)** - The oxidation number of the hydrogen element increases from 0 to + 1 (it undergoes oxidation). **(0.25 pt)** - Since the oxidation numbers vary between reactants and product so the reaction is an oxidation-reduction reaction. **(0.25 pt)**	**1.5**
4.2	- The oxidation number of chlorine element decreases from 0 to −1 **(0.25 pt)**. Cl_2 undergoes reduction then Cl_2 is the oxidant (oxidizing agent). **(0.5 pt)**	**0.75**

Part of the Q	Exercise 3 (7 points) $\qquad$ Electrochemical Cell Expected answers	Mark
1.1	In an electrochemical cell, electrons flow from the anode to the cathode. In this cell, electrons flow from Cu strip to Ag strip then Cu is the anode in this cell.	1
1.2	$Cu\|Cu^{2+}$ – salt bridge – $Ag^+\|Ag$	1
2	In this cell, Cu undergoes oxidation then Cu has more tendency to lose electrons than Ag. **(0.5 pt)** Ag $\qquad$ Cu $\qquad$ **Increasing tendency to lose electrons** $\qquad\qquad\qquad\qquad\qquad\qquad$ **(0.5 pt)**	1
3	At the anode oxidation half-reaction: **$Cu \rightarrow Cu^{2+} +2\ e^-$** $\quad$ **(0.5 pt)** At the cathode reduction half-reaction : $\ Ag^+ + 1\ e^- \rightarrow Ag$ **(0.5 pt)**	1
4	In a redox reaction, the number of electrons lost is equal to the number of electrons gained. **(0.25pt)** $\qquad\qquad\qquad Cu \rightarrow Cu^{2+} + 2e^-$ $\qquad\qquad +$ $\qquad\qquad 2Ag^+ + 2e^- \rightarrow 2\ Ag$ _(multiply reduction ½ reaction by 2)_ $\qquad\qquad Cu + 2Ag^+ \rightarrow Cu^{2+} + 2Ag$ $\qquad\qquad$ **(0.75 pt)**. The overall equation of the reaction is: $\quad Cu + 2Ag^+ \rightarrow Cu^{2+} + 2Ag$ **(0.5pt)**	1.5
5.1	When the cell G_1 is functioning, copper undergoes oxidation, it is oxidized into Cu^{+2} ions, then the mass of copper strip decreases.	0.75
5.2	When the salt bridge is removed, the circuit becomes open then the lamp stops glowing.	0.75