This Exam Includes Three Exercises. It Is Inscribed on Two Pages.
Answer the Following Three Exercises. Use of Non-programmable Calculator Is Allowed.
**First Exercise (7 points)**
The Simplest Alcohol: Methanol

Methanol is a light, volatile, colorless, flammable liquid with a distinctive odor very similar to, but slightly sweeter than, ethanol. The main uses of methanol are the production of formaldehyde and more recently as fuel component; as a solvent for organic compounds and as an intermediate product to manufacture polyester fibres.

1- Methanol is a mono alcohol which satisfies the general formula $C_nH_{(2n+1)}$ OH , where n is an integer.
  - Give the value of n for the compound methanol and the name of the functional group of methanol.
2- Two compounds (**E**) and (**F**) that can be derived from methanol are given below:

$$(E) \text{ Chloromethane} \longleftarrow \text{ Methanol } \longrightarrow H-\overset{\overset{\displaystyle O}{\|}}{C}-OH \text{ (F)}$$
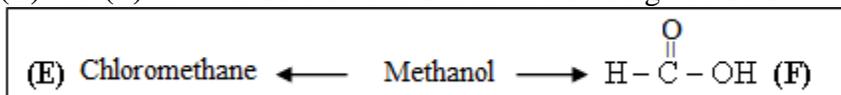
  - Choose among the following names the one that corresponds to the IUPAC name of compound (**F**).
    a- Formic acid   **b**-Methanoic acid   **c**-Carboxylic acid
3- Chloromethane can be obtained according to the following reaction:
    $CH_3OH + PCl_5 \rightarrow$ chloromethane $+ POCl_3 + HCl$
  -Show that the molecular formula of chloromethane is CH_3Cl.
4- Another possible method to obtain chloromethane is from substitution reaction of methane where **o**ne molecule of methane reacts with one molecule of chlorine (Cl_2) gas, in the presence of sunlight. The products of the reaction are one molecule of hydrogen chloride and one molecule of chloromethane.
  4.1- Translate, using chemical formulas, the preceding information into an equation form.
  4.2- Justify why methane is a saturated hydrocarbon.
5- Chloroethane can be obtained from addition reaction of one molecule of hydrogen chloride with one molecule of ethene.
  - Distinguish the substitution reaction of methane from the addition reaction of ethene.
6- Pick out from the text two uses and two physical properties of methanol.

Second Exercise (7 points)
Transportation Contributes to Air Pollution

Many toxic gases that have harmful effects on the environment are produced from the exhausts of vehicles. One of these gases is nitric oxide NO which contributes to acid rain formation.
The Lewis dot structure of each of oxygen molecule and of nitrogen molecule is given respectively:

$$:\overset{..}{\underset{..}{O}}=\overset{..}{\underset{..}{O}}: \quad \text{and} \quad :N\equiv N:$$

1- Referring to the preceding Lewis dot structures:
  1.1- Identify the type of bonding in nitrogen molecule.
  1.2- Deduce the valence of the nitrogen atom.
2- Give the number of lone pairs of electrons for oxygen atom.
3- Specify to which column (group) in the periodic table oxygen belongs.
4-Nitric oxide released into the air from the exhausts of vehicles reacts with oxygen gas to form nitrogen dioxide NO_2 gas.
-Complete the equation: $2NO + O_2 \rightarrow$ ....
5-Harmful consequences of acid rain results due to the production of the gas nitric oxide from the

exhausts of vehicles. Acid rain damages the root of trees, kills the micro-organisms found in the soil and deteriorates stone buildings and statues. The bar graph given shows the quantity of nitrogen dioxide gas NO_2 formed in air over the years.

5.1- Compare the numerical value of the quantity of NO_2 formed in the air in year 2006 to the numerical value of the quantity formed in year 2009.

5.2- Indicate, referring to the bar graph and to the text, in which year the contribution of nitric oxide to acid rain formation is the greatest. Justify.

5.3-Pick out from the text two harmful effects of acid rain on the environment.

Quantity of NO_2 gas formed in air over the years
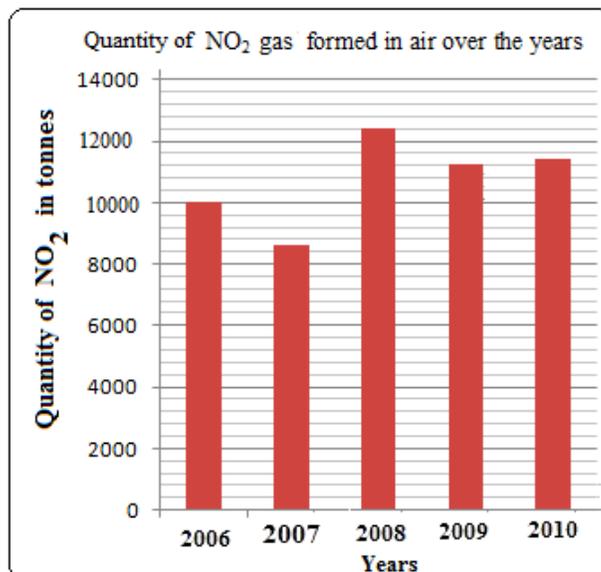
Third Exercise (6 points)

Three Galvanic Cells

Galvanic cells produce direct current. Below is given:

- The written cell representations of two functioning galvanic cells G1 and G2.

- Written cell representation of galvanic cell G1: $Mg^{2+}|$ Mg – salt bridge – $Zn^{2+}|Zn$
- Written cell representation of galvanic cell G2: $Zn^{2+}|$ Zn – salt bridge – $Cu^{2+}|Cu$

- The schema of incomplete galvanic cell G3 and the schema of functioning galvanic cell G1.
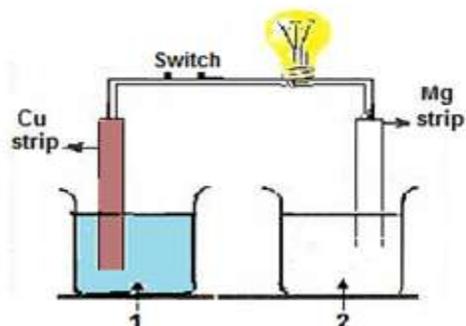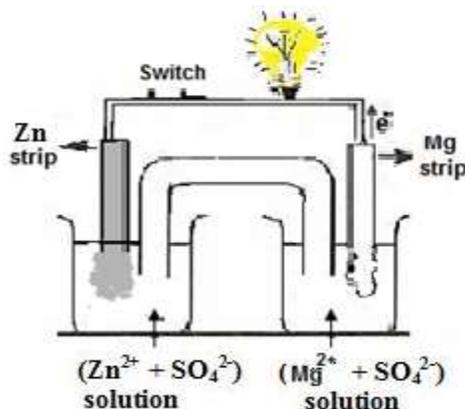
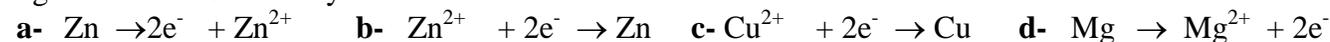Schema of incomplete galvanic cell G3   Schema of functioning galvanic cell G1

1- Label the solution in each of the two beakers 1 and 2 of the schema of the incomplete galvanic cell G3.

2- When the missing component of galvanic cell G3 is added; the galvanic cell G3 functions and the lamp lights.

  - Specify the role of the missing component.

3- Deduce, based on the given, that the copper (Cu) strip is the cathode of galvanic cell G3.

4-Write the half-reaction that takes place at the anode of the galvanic cell G3 when the lamp lights.

5-Choose among the following half-reactions the one that explains what takes place at the cathode of galvanic cell G1. Justify.

a- $Zn \rightarrow 2e^- + Zn^{2+}$ **b-** $Zn^{2+} + 2e^- \rightarrow Zn$ **c-** $Cu^{2+} + 2e^- \rightarrow Cu$ **d-** $Mg \rightarrow Mg^{2+} + 2e^-$

6-The salt bridge contains jellified electrolyte potassium nitrate $(K^+ + NO_3^-)$.

 -Explain, why the K^+ ions and the NO_3^- ions of the salt bridge move at the same time respectively into the solution of the cathode half-cell and the solution of the anode half cell of the functioning galvanic cell G1.

First Exercise (7 points)

Part of the Q	Answer	Mark
1	**For** methanol **n** =1 **0.5 pt** , functional group is hydroxyl group **0.5pt**	1
2	b) or methanoic acid **0.5 pt**	0.5
3	Let the molecular formula be $C_x H_y Cl_z$, according to law of conservation of mass (atoms), for the same element the number of atoms is equal before and after the reaction. For C: 1 = x, for H: 4= y+1 => y=3 ; for P: 1=1; for Cl: 5= 3 +1 +z => z=1 The molecular formula of chloromethane is CH_3Cl	1
4.1	CH_4 + Cl_2 $\rightarrow$ CH_3Cl + HCl	1
4.2	Methane of molecular formula CH_4 is an alkane. It is a saturated hydrocarbon because the carbon atom holds the maximum number of hydrogen atoms. (carbon atom makes four single covalent bonds).	1
5	In substitution reaction of methane, a hydrogen atom is replaced by a chlorine atom. **0.75 pt** In addition reaction of ethene, one of the bonds of the double covalent bond between the carbon atoms of ethene molecule breaks, the hydrogen atom of hydrogen chloride molecule is attached to one of the carbon atoms and the chlorine atom is attached to the other carbon atom. **0.75 pt**	1.5
6	Production of formaldehyde, and more recently as fuel component... **0.25 pt x 4** Volatile lquid, colorless,...	1

Second Exercise (7 points)

Part of the Q	Answer	Mark
1.1	The type of bonding in nitrogen molecule is triple covalent bond due to sharing of three pairs of electrons by the two nitrogen atoms.	0.5
1.2	The valence of an element indicates the number of electrons involved in bonding to achieve the electron configuration of the closest inert gas. According to Lewis dot structure of nitrogen molecule, the number of electrons for a nitrogen atom involved in bonding is 3. The valence of nitrogen atom is 3.	1
2	The number of lone pairs of electrons for an oxygen atom is 2.	0.5
3	Oxygen atom has two lone pairs of unshared electrons and a pair of shared electrons. Total number of valence electrons = 6. The number of electrons on the valence energy level determines the group in the periodic table (or the unit digit of the column number) => oxygen belongs to group VI or column 16.	1
4	The equation is : $2NO$ + O_2 $\rightarrow 2NO_2$	0.5

5.1	Quantity of NO_2 gas formed in air in year 2006 is 10000 tonnes **0.25 pt** Quantity of NO_2 gas formed in air in year 2009 is 10600 tonnes **0.25 pt** Numerical value 10600 > 10000 **0.5 pt** *Quantity of NO_2 gas formed in the air in 2009 > Quantity of NO_2 gas formed in 2006.*	**1**
5.2	The contribution is greatest in year 2008. **0.5pt** Quantity of NO_2 gas formed in air in year 2008 is maximum 124000 tonnes. According to part (4), nitrogen dioxide results from the reaction of nitric oxide with oxygen. The grater the quantity of NO_2 => the greater is the quantity of NO released into the air => the greater is the contribution of nitric oxide to acid rain formation. **1pt**	**1.5**
5.3	Two harmful effects of acid rain on the environment are: Acid rain damages the roots of trees, kills the micro-organisms found in the soil …	**1**

Third Exercise (6 points)

Part of the Q	Answer	Mark
1	In beaker (1) Copper II sulfate solution($Cu^{2+} + SO_4^{2-}$) **0.5 pt** In beaker (2) Magnesium sulfate solution ($Mg^{2+} + SO_4^{2-}$) **0.5 pt**	**1**
2	Salt bridge allows the ions to move through it in opposite directions, to keep charge balance in the two solutions and to ensure the flow of electrons through the external part of the galvanic cell.	**1**
3	In galvanic cell G2, Cu is the cathode, has less tendency to lose electrons than Zn. In galvanic cell G1, Zn is the cathode, has less tendency to lose electrons than Mg. ⇨ Copper Cu has, less tendency to lose electrons than Mg. In galvanic cell G3, Cu is the cathode.	**1**
4	The half reaction that takes place at the anode of galvanic cell G3 is: $Mg \rightarrow 2e^- + Mg^{2+}$	**0.5**
5	Half-reaction is: **b) or** $Zn^{2+} + 2e^- \rightarrow Zn$ **0.5pt** Zinc strip, becomes thicker, is the cathode of galvanic cell G1; in the cathodic half cell. zinc ion in the solution captures 2electrons at the surface of the zinc strip and is reduced to Zn atom and is deposited on the zinc strip.**1pt**	**1.5**
6	When the galvanic cell functions, oxidation of Mg atoms to Mg^{2+} ions occurs at the anode and the positive charge increases in the solution, and at the same time reduction of Zn^{2+} ions to Zn atoms occurs at the cathode and the negative charge increases in the solution, the displacement of the ions of salt bridge occur at the same time to keep charge balance of the solutions in the two half-cells.	**1**