مسابقة في مادة الكيمياء المدة: ساعة واحدة الرقم:

This Exam Is Composed of Three Exercises. It Is Inscribed on 2 Pages. Answer the Following Three Exercises.

# First Exercise (6 points) Gaseous Pollutants

Pollution occurs when harmful materials are released into the environment in amounts exceeding their tolerable level. Gaseous air pollutants such as carbon dioxide  $CO_2$ , sulfur dioxide  $SO_2$  and nitric oxide NO are released into air from combustion of fossil fuels (heavy fuel, charcoal, gasoline ....). In the presence of humidity in air, these gases form compounds  $H_2SO_4$ ,  $H_2CO_3$ ,  $HNO_3$  that cause acid rain.

**Given:** Electron configuration of:

<sub>1</sub> H: K <sup>1</sup> ;	<sub>6</sub> C: K	$^{2},L^{4}$ ;	7N: K	$L^2, L^5$
8O: K <sup>2</sup> , L	$^{6}$ and	16S: K	$L^2, L^8, N$	<b>1</b> <sup>6</sup>

Table of Gaseous Pollutants of Air				
Pollutants	Tolerable level of some gaseous pollutants in air $(\mu g / m^3)$ .			
Carbon monoxide	10000			
Carbon dioxide	7500			
Nitrogen dioxide	120			
Ozone	100			
Sulfur dioxide	75			

- **1-** Identify among the given atoms (H, C, N, O, and S) those that belong to the same period (row) and those that belong to the same column(group).
- 2- Write the Lewis electron-dot symbol of the atoms composing carbon dioxide molecule.
- **3-** Explain the bond formation in carbon dioxide molecule.
- **4-** In an industrial region ( $\mathbf{R}$ ) the amount of carbon dioxide in air is 7000  $\mu$ g / m<sup>3</sup> and that of sulfur dioxide is 95  $\mu$ g / m<sup>3</sup>.

The air in the industrial region  $(\mathbf{R})$  is polluted .Justify.

# Second Exercise (7 Points) Petroleum and Natural Gas

Petroleum and natural gas are fossil fuels; they are made of compounds called hydrocarbons. Compound (**H**) is a hydrocarbon. A molecule of compound (**H**) contains 4 carbon atoms and 10 hydrogen atoms.

- **1-** Give the significance of the term hydrocarbon.
- **2-** Write the condensed structural formulas of all possible isomers of hydrocarbon (**H**) and give the (IUPAC) systematic name of each isomer.
- **3-** Open chain hydrocarbons can be alkanes, alkenes and alkynes. Show that compound (**H**) is an alkane.

### Air **Pollutants**

roleum is separated into several kinds of products in the refineries. cracking of an alkane (A) gives hexane ( $C_6H_{14}$ ) and an alkene (P). The number of carbon atoms in a molecule of alkene (**P**) is 3. The equation of the cracking of (**A**) is:

$$(A) \rightarrow C_6H_{14} + (P)$$

- a) Determine the number of the carbon atoms and the number of hydrogen atoms in a molecule of alkane (A).
- **b**) Write the structural formula of (**P**) and indicate the type of bonds between its carbon atoms.

### Third Exercise (7 points) **Redox Reaction: Corrosion of Iron**

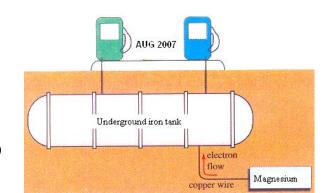
Corrosion of underground metallic iron pipes and tanks can be greatly prevented by connecting the pipes or the tanks to an active metal such as zinc or magnesium.

#### Given:

-Consider the reaction represented by the following equation:

$$3Mg_{(s)} + Fe_2O_3_{(s)} \longrightarrow 2Fe_{(s)} + 3MgO_{(s)}$$
 (1)

- The oxidation number of oxygen is (-2).



- 1- Show, using oxidation numbers, that the reaction represented by equation (1) is an oxidation reduction reaction.
- **2-** Identify the oxidant in the given reaction.
- 3- Choose from the following half-reactions, those that can be associated to the above reaction as oxidation half-reaction and reduction half-reaction. Justify.

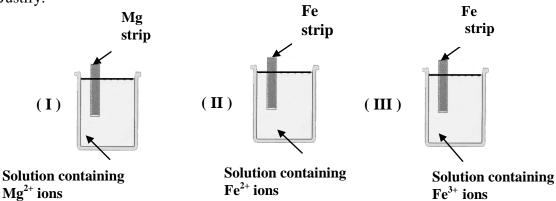
a) 
$$3Mg^{2+} + 6e^{-} \longrightarrow 3Mg$$
  
b)  $Fe^{3+} + 3e^{-} \longrightarrow Fe$   
c)  $Mg \longrightarrow Mg^{2+} + 2e^{-}$   
d)  $2Fe \longrightarrow 2 Fe^{3+} + 6e^{-}$ 

b) 
$$Fe^{3+} + 3e^{-} \longrightarrow Fe^{3+} \longrightarrow Fe$$

- **4-**State, based on the text, how corrosion of underground iron storage tanks can be prevented.
- 5-A student makes a galvanic cell (G) based on the following spontaneous redox reaction.

$$Mg + Fe^{2+} \longrightarrow Mg^{2+} + Fe$$
 (2)

Indicate among the given half-cells (I), (II) and (III) which half-cell cannot be associated to galvanic cell **(G).** Justify.



# Chemistry BE-9

# 2<sup>nd</sup> Session 2007

## **Marking Scheme**

Expected Answers		Comments	
First Exercise ( 6 Points)	Marks		
<ul> <li>1- The elements that belong to the same period (row) are C, N, and O because they have the same number of occupied energy levels.</li> <li>- The elements that belong to the same group (column) are O and S because they have the same number of electrons on the outer energy level.</li> </ul>	1	-Group and period based on electron configuration then deduce. Whole mark. - No deduction(1pt)	
2- The Lewis electron-dot symbol of the atoms composing carbon dioxide molecule are:			
. C. :O.	2 x ½		
<b>3-</b> The carbon atom has 4 valence electrons, it needs four electrons to attain octet.	1/2	-Explaining based on Lewis dot structure of CO <sub>2</sub>	
An oxygen atom has 6 valence electrons, it needs two electrons to attain octet.	1/2	molecule: acceptable -All other logical reasoning	
Each oxygen atom shares two pairs of electrons with C atom to have octet of electrons on its valence energy level to form CO <sub>2</sub> molecule.	1	is acceptable	
<b>4-</b> In the industrial region ( <b>R</b> ), the amount of carbon dioxide is $7000  \mu g.m^{-3} < 7500  \mu g.m^{-3}$ . It is not polluted with respect to CO <sub>2</sub> Whereas, the sulfur dioxide level is $95  \mu g.m^{-3} > 75  \mu g.m^{-3}$ . It is polluted due to SO <sub>2</sub> .	1	-Justification based on SO <sub>2</sub> only: acceptable	
Second Exercise (7 Points)			
1- Hydrocarbon is an organic compound composed only of the elements Carbon and Hydrogen.		-Chemical compound of formula C <sub>x</sub> H <sub>y</sub> : acceptable.	
<b>2-</b> The condensed structural formulas of all possible isomers of hydrocarbon ( <b>H</b> ) are:			
$CH_3$ - $CH_2$ - $CH_3$ $CH_3$ - $CH(CH_3)$ - $CH_3$	$2x^{1/2}$		
Butane 2-methylpropane	2x½	Methylpropane:acceptable.	
3- Alkanes satisfy the general formula $:C_nH_{2n+2}$	1/4	-All bonds C-C in the	
Compound (H) has 4 carbon atoms and 10 hydrogen atoms For $C$ : $n = 4$ : For $H : 2n + 2 = 2x + 4 + 2 = 8$	1	isomers of ( <b>H</b> ) are single covalent bond => ( <b>H</b> ) is	
For C: $n = 4$ ; For $\mathbf{H}$ : $2n+2 = 2x4+2=8+2=10$ => ( $\mathbf{H}$ ) is an alkane.	1	an alkane.  - C <sub>4</sub> H <sub>10</sub> is compatible with C <sub>n</sub> H <sub>2n+2</sub> => ( <b>H</b> ) is an alkane.	
	_		

4- a) Alkene admits the general formula C <sub>n</sub> H <sub>2n</sub> since		TT1 C 1 C (TD) :
		-The formula of ( <b>P</b> ) is
the number of carbon atoms in alkene ( <b>P</b> ) is 3	1/2	C <sub>3</sub> H <sub>6</sub> :acceptable
=> The molecular formula of (P) is: C <sub>3</sub> H <sub>6</sub>		
The equation of the cracking of (A) is:		
$(A) \longrightarrow C_6H_{14} + C_3H_6$		
According to the Law of conservation of mass (atoms are		
conserved)	1/4	
Number of carbon atoms <b>C</b> ( <b>reactant side</b> ) = number of	, ,	
carbon atoms C( product side) = $6+3=9$		
Number of hydrogen atoms <b>H</b> ( <b>reactant side</b> ) = number of		$n_{x} = 0$ with (A) is on
		$-n_C = 9$ with (A) is an
hydrogen atoms $H(\text{product side}) = 14+6 = 20$		alkane $(C_nH_{2n+2}) =>$
<b>b</b> ) the structural formula of ( <b>P</b> ) C <sub>3</sub> H <sub>6</sub> is:		the formula is $C_9H_{20}$
		$n_{\rm H} = 20.$
н н н		
$H \mp C \mp C \longrightarrow C \mp H$		
	1/2	
H		
The type of bonds between its carbon atoms are:		
C = C double covalent bond	1/2	-Double bond (zero)
C C double covarent bond	1/2	- Single bond (zero)
	72	- Single bolid (zero)
Third Exercise(7 Points)  1-		One justification is
		-One justification is
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	4 1/	acceptable.
$3Mg_{(s)} + Fe_2O_3_{(s)} \longrightarrow 2Fe_{(s)} + 3MgO_{(s)}$	$4x^{1/4}$	- Change in the oxidation
The oxidation number of Mg increased from 0 to +2:		number of the reactants
oxidation		=> oxidation-reduction
The oxidation number of Fe decreased from +3 to 0:	1	reaction
reduction		
=> Oxidation-reduction reaction.		
-> Oxidation reduction.		
	1	- $\mathbf{Fe}^{3+}$ in $\mathbf{Fe}_2\mathbf{O}_3$ is the
2- Fe <sup>3+</sup> in Fe <sub>2</sub> O <sub>3</sub> is the oxidant, since it undergoes reduction.	1	- Fe <sup>3+</sup> in Fe <sub>2</sub> O <sub>3</sub> is the oxidant because there is
2- Fe <sup>3+</sup> in Fe <sub>2</sub> O <sub>3</sub> is the oxidant, since it undergoes	1	
2- Fe <sup>3+</sup> in Fe <sub>2</sub> O <sub>3</sub> is the oxidant, since it undergoes	1	oxidant because there is decrease in the oxidation number
<ul> <li>2- Fe<sup>3+</sup> in Fe<sub>2</sub>O<sub>3</sub> is the oxidant, since it undergoes reduction.</li> <li>3- The following half-reactions :</li> </ul>	1	oxidant because there is decrease in the oxidation
<ul> <li>2- Fe<sup>3+</sup> in Fe<sub>2</sub>O<sub>3</sub> is the oxidant, since it undergoes reduction.</li> <li>3- The following half-reactions :</li> </ul>	1 1/2	oxidant because there is decrease in the oxidation number - b and c are acceptable.
2- Fe <sup>3+</sup> in Fe <sub>2</sub> O <sub>3</sub> is the oxidant, since it undergoes reduction.	1/2	oxidant because there is decrease in the oxidation number  - b and c are acceptable.  - Logical reasoning
2- Fe <sup>3+</sup> in Fe <sub>2</sub> O <sub>3</sub> is the oxidant, since it undergoes reduction.  3- The following half-reactions:  Mg   Mg <sup>2+</sup> + 2e <sup>-</sup> : oxidation Fe <sup>3+</sup> + 3e <sup>-</sup> Fe : reduction		oxidant because there is decrease in the oxidation number  - b and c are acceptable.  - Logical reasoning compatible with equation
2- Fe <sup>3+</sup> in Fe <sub>2</sub> O <sub>3</sub> is the oxidant, since it undergoes reduction.  3- The following half-reactions:  Mg → Mg <sup>2+</sup> + 2e <sup>-</sup> : oxidation  Fe <sup>3+</sup> + 3e <sup>-</sup> → Fe: reduction are associated to the reaction represented by equation (1)	1/2 1/2	oxidant because there is decrease in the oxidation number  - b and c are acceptable.  - Logical reasoning
2- Fe <sup>3+</sup> in Fe <sub>2</sub> O <sub>3</sub> is the oxidant, since it undergoes reduction.  3- The following half-reactions:  Mg → Mg <sup>2+</sup> + 2e <sup>-</sup> : oxidation  Fe <sup>3+</sup> + 3e <sup>-</sup> → Fe: reduction  are associated to the reaction represented by equation (1) because Mg undergoes oxidation and Fe <sup>3+</sup> undergoes	1/2 1/2	oxidant because there is decrease in the oxidation number  - b and c are acceptable.  - Logical reasoning compatible with equation
2- Fe <sup>3+</sup> in Fe <sub>2</sub> O <sub>3</sub> is the oxidant, since it undergoes reduction.  3- The following half-reactions:  Mg → Mg <sup>2+</sup> + 2e <sup>-</sup> : oxidation  Fe <sup>3+</sup> + 3e <sup>-</sup> → Fe: reduction are associated to the reaction represented by equation (1) because Mg undergoes oxidation and Fe <sup>3+</sup> undergoes reduction.	1/2 1/2 1	oxidant because there is decrease in the oxidation number  - b and c are acceptable.  - Logical reasoning compatible with equation
2- Fe³+ in Fe₂O₃ is the oxidant, since it undergoes reduction.  3- The following half-reactions:  Mg → Mg²+ + 2e⁻: oxidation  Fe³+ + 3e⁻ → Fe : reduction  are associated to the reaction represented by equation (1) because Mg undergoes oxidation and Fe³+ undergoes reduction.  4- Iron storage tanks can be prevented from rusting by	1/2 1/2	oxidant because there is decrease in the oxidation number  - b and c are acceptable.  - Logical reasoning compatible with equation
2- Fe³+ in Fe₂O₃ is the oxidant, since it undergoes reduction.  3- The following half-reactions:  Mg → Mg²+ + 2e⁻: oxidation  Fe³+ + 3e⁻ → Fe : reduction  are associated to the reaction represented by equation (1) because Mg undergoes oxidation and Fe³+ undergoes reduction.  4- Iron storage tanks can be prevented from rusting by connecting to an active metal such as zinc or magnesium.	1/2 1/2 1 1	oxidant because there is decrease in the oxidation number  - b and c are acceptable.  - Logical reasoning compatible with equation (1): acceptable.
<ul> <li>2- Fe<sup>3+</sup> in Fe<sub>2</sub>O<sub>3</sub> is the oxidant, since it undergoes reduction.</li> <li>3- The following half-reactions: Mg → Mg<sup>2+</sup> + 2e<sup>-</sup>: oxidation Fe<sup>3+</sup> + 3e<sup>-</sup> → Fe: reduction are associated to the reaction represented by equation (1) because Mg undergoes oxidation and Fe<sup>3+</sup> undergoes reduction. </li> <li>4- Iron storage tanks can be prevented from rusting by connecting to an active metal such as zinc or magnesium.</li> <li>5-The half-cell which cannot be associated to galvanic cell</li> </ul>	1/2 1/2 1	oxidant because there is decrease in the oxidation number  - b and c are acceptable.  - Logical reasoning compatible with equation (1): acceptable.  -Deduction by elimination
2- Fe³+ in Fe₂O₃ is the oxidant, since it undergoes reduction.  3- The following half-reactions:  Mg → Mg²+ + 2e⁻: oxidation  Fe³+ + 3e⁻ → Fe : reduction  are associated to the reaction represented by equation (1) because Mg undergoes oxidation and Fe³+ undergoes reduction.  4- Iron storage tanks can be prevented from rusting by connecting to an active metal such as zinc or magnesium.  5-The half-cell which cannot be associated to galvanic cell (G) is the half-cell (III).	1/2 1/2 1	oxidant because there is decrease in the oxidation number  - b and c are acceptable.  - Logical reasoning compatible with equation (1): acceptable.
<ul> <li>2- Fe<sup>3+</sup> in Fe<sub>2</sub>O<sub>3</sub> is the oxidant, since it undergoes reduction.</li> <li>3- The following half-reactions: Mg → Mg<sup>2+</sup> + 2e<sup>-</sup>: oxidation Fe<sup>3+</sup> + 3e<sup>-</sup> → Fe: reduction are associated to the reaction represented by equation (1) because Mg undergoes oxidation and Fe<sup>3+</sup> undergoes reduction. </li> <li>4- Iron storage tanks can be prevented from rusting by connecting to an active metal such as zinc or magnesium.</li> <li>5-The half-cell which cannot be associated to galvanic cell (G) is the half-cell (III).</li> <li>The Iron ion involved in the overall reaction of the galvanic</li> </ul>	1/2 1/2 1 1	oxidant because there is decrease in the oxidation number  - b and c are acceptable.  - Logical reasoning compatible with equation (1): acceptable.  -Deduction by elimination
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