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## Introduction

If we consume 1kg of food, 2kgs of water, we consume 20kgs of air daily (Lacombe, 2015).

With each breathe we fill our lungs with air, composed of nitrogen and oxygen gases, with these gases we also introduce other gases and particulate matter, some of which are toxic to our health. These toxic gases and particulate matter came from our cars, our heating system, our vegetation and our smoke, another portion came from natural forests fire and from earth surface dust.

Earth atmosphere is like an apple peel compared to earth volume, but it is essential for the life of every living organism on earth, without this atmosphere, earth is not a good place to live in.

Air is the most important element for us to live. We can stand hunger and thirst for days, but we can't stand life without breathing for more than 10 seconds.

Fresh natural air constitutes naturally from nitrogen, oxygen and other gases such as argon, ozone, hydrogen, water vapor and traces of other gases.

Pollution in any system can be defined as anything added to the system and causes a change in its physical, chemical or biological structure and causes a deviation in its proper mission.

Air pollution is a very critical matter, hence air is a vulnerable system which can be affected quickly by anthropogenic activities and natural pollutants.

Air pollutants are divided into two main types. Primary pollutants, which are introduced into air either from anthropogenic actions, like car emissions heating systems and industrial emissions, or from natural sources like emission of volatile organic compounds from vegetation and trees. These primary pollutants are pollutants by themselves and have direct effect on human health, water

bodies and buildings. Second, Secondary pollutants, which are derived from the reactions of primary pollutants with ozone, oxygen and water vapor.

In this exam, the answers of the supplied questions illustrates many of air pollution schemes and points out to the dangers of air pollutants on health and nature.

## Answers to Questions

1. What chemicals in the air are defined as air pollutants?

Answer:

Pure air consists of the main gases: 78% Nitrogen, 21% Oxygen, and 1% of other gases such as carbon dioxide, argon, ozone, hydrogen and water vapor.

Any other gases or particulate matter in air are called air pollutants, these are like:

- Sulfur dioxide SO<sub>2</sub>
- Carbon monoxide CO
- Nitrogen Oxides, NOx
- Volatile organic compounds VOC's
- Inorganic salts such as NaCl, Na<sub>2</sub>SO<sub>4</sub>, from ocean aerosol.
- Greenhouse gases like Methane (CH<sub>4</sub>) and Carbon dioxide (CO<sub>2</sub>)
- Particulate matter such as traces of metals like lead, copper and iron
- Dust from earth surface, smoke and ash which are mainly unburned carbon atoms

2. What are primary pollutants? Give 4 examples.

Answer:

Primary pollutants are those materials that goes directly into atmosphere, and they are pollutants by themselves such as:

- a- Sulfur dioxide,  $\text{SO}_2$ , which comes from burning coal and oil in power plants, smelting industries, heating devices and petroleum refineries.
- b- Volatile Organic Compounds VOCs, such as methane, benzene and benzo-a- pyrene, formalin, ethylene, chlorinated hydrocarbons; these chemicals come from chemical industries and burning of wood.
- c- Carbon dioxide  $\text{CO}_2$ , comes from burning of woods and a product of aerobic bacterial digestion of wastes in landfills and as a greenhouse gas.
- d- Carbon monoxide CO, which comes from burning of woods, heating devices and automobile exhausts.
3. What are VOCs? What is NOx? What is  $\text{SO}_2$ ? What are the sources of these chemicals?

Answer:

-Volatile Organic Compounds (VOCs) are organic compounds with a high volatility and low boiling points, they come from vapors of petroleum pilot plants, automobile exhausts, paint factories and vegetation chemicals and from fermentation of solid wastes.

-Nitrogen Oxides or NOx, are oxides of nitrogen such as  $\text{NO}_2$ ,  $\text{N}_2\text{O}$ ,  $\text{N}_2\text{O}_4$ , NO, They are formed upon reaction of pure nitrogen with Oxygen in the atmosphere.

NO or nitrogen monoxide mainly comes from airplanes exhaust.

-Sulfur dioxide ( $\text{SO}_2$ ) is one of sulfur oxides, which is produced from petroleum refineries and from burning of material containing sulfur element, it can be readily oxides to sulfur trioxide which is used in the industry of sulfuric acid. Sulfur dioxide is a primary air pollutant, it is responsible on the formation of acid rain over big industrial cities.

4. What are secondary pollutants? Give 2 examples.

Answer:

Secondary pollutants are those chemicals which are introduced into atmosphere and are not considered pollutants until they react with other chemicals to produce pollutants for example:

- a- Sulfuric acid  $H_2SO_4$ , which comes from the reaction of sulfur trioxide  $SO_3$  with water molecules in the atmosphere to form Sulfuric acid which is called acid rain.
- b- Nitric acid  $HNO_3$  which is the product of the reaction between  $NO_x$  and water molecules in the atmosphere, causing acid rain that affects.

Acid rain has adverse effect on human health, water bodies, building, soil, trees and vegetation.

5. What adverse health effects are caused by air pollution? Describe them.

Answer:

- a- Heart Disease: Elderly people, who have a history in heart problems are most likely to be affected badly upon exposure to air pollutants especially particulate matter of size between  $2.5 - 10\mu m$  and to nitrogen dioxide emitted from motor vehicles. An Increase of the chambers of the heart, the left and the right ventricle was reported. ( Davis, 2018)
- b- Lung disease: The exposure to air pollutants such as asbestos and organic compounds is associated with many respiratory system such increase of lung cancer, asthma, chest tightness, cough and phlegm and irritation in thought and increase incidence of acute upper respiratory infections that interfere with normal activity. (Jiang, 2018).
- c- Cancer: The evidence that outdoor air pollution increases the risk of cancer has been growing (Williams, 2013). The particulate matter (PM) such as asbestos and smoke are

classified as a major cause of lung cancer. Poly Aromatic Hydrocarbons (PAHs) and automobile emissions are individually linked to cancer.

- d - Lead particle in the atmosphere, which comes from the automobile emissions, aviation and smelting industries, accumulate in bones and the nervous systems of humans the stomach causing nausea, vomiting and may end with death and have adverse on kidney functions, cardiovascular system, reproductive system and immune system.(EPA)
- d- Benzo – a- Pyrene which comes from burning of fats in the presence of carbon, may cause cancer.

6. Describe an air inversion and how it contributes to air pollution.

Answer:

An inversion is the change of the temperature / altitude theme occurs in the troposphere.

The usual temperature theme is that the higher we go up from ground surface the cooler the air. In an inversion condition, a warm air layer stands on a cooler layer, and that happens when no wind moves and after a sunny day, where the of the earth's surface was heated by sun radiation and when a sudden wind front comes and the warm air moves up over the cooled layer.

The air pollutants from anthropogenic activities like smog , VOCs and particulate matter, become more condensed and less dispersed, which adversely affects human life and has sever effect on plants and other forms of life.

This case lasts until wind moves again and disperse pollutants in wider areas.

7. Describe photochemical smog.

Answer:

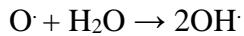
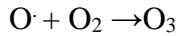
Smog is the combination of smoke and fog, while photochemical smog is caused from the reaction of nitrogen oxides NOx and volatile Organic compounds VOCs which comes from

anthropogenic activities and from vegetation fermentation and sunlight. Ground level ozone is produced on the expense of consuming oxygen, which causes eyes irritation and breathing problems for those who susceptible to lung disease and breathing problems. Ground level ozone is a major air pollutant, its concentration is used as a measure of air pollution. (Manahan, 1994), whereas ozone in the stratosphere protects life on earth from the sun's harmful ultraviolet rays (Ahrens, 2011).

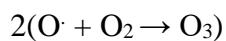
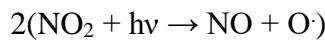
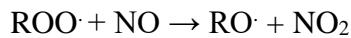
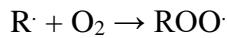
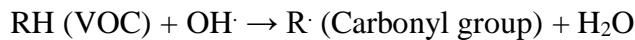
The following equations illustrates the Photochemical smog



The produced atomic oxygen, is called free radical; free radicals are very reactive species, they react with molecular oxygen and with water molecules in the troposphere as follows:



A sample reaction scheme of VOCs, NOx, water molecules and solar radiation is illustrated in the following chemical equations (Carter, 1999) :



RH represents a volatile organic compound.

8. How is air pollution controlled? Describe 3 ways to control air pollution.

Answer:

Understanding the sources of air pollution is an essential step on the way to control air pollution and by reducing the amount of air pollutants is essential for human health and environment.

Air pollution can be controlled through:

- 1- Legislation acts by governments and environmental associations on global scale, to reduce the amounts of gases emitted in the atmosphere. As an example for reducing particulate matter from industrial plants is the obligation to install solid particle filters before releasing wastes into air.
- 2- Technology; by applying catalytic invertors in cars and other industrial machines which depend on petroleum products in its work, as an obligation act, to reduce the emission of NOx.
- 3- Public awareness on the necessity to reduce the dependence on fuel and wood for the purpose of heating and automobile engines and replace it with clean solar energy. Encouraging the use bikes for local transportation in big industrial cities, where air pollution is dominant.

## Conclusion

Human activities have the lion share in air pollution, it is believed that more than 50% of air pollutants come from human activities. Legislations must be done as an urgent call to reduce amounts of air pollutants in our environment.

It is not the responsibility of governments alone to reduce the risk of air pollution, but individuals and community organizations must do their part in terms of individual and collective awareness to reduce the risk of air pollution.

It should also be taken into account that air pollution is a global danger. If pollution is spread in a particular country, the danger spreads to neighboring countries and regions. We have a good lesson from Chernobyl accident in the 1986, when air was polluted with radiation particle over many parts of Europe, and all the world have experienced the magnitude of the threat to Earth.

Global efforts for the control of air pollution have met success in many areas, especially the legislation acts for the remediation of ozone hole.

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