



MACHAKOS UNIVERSITY

University Examinations 2021/2022

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FOURTH YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF EDUCATION (SCIENCE)

SECOND YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN ANALYTICAL CHEMISTRY

SCH 407/SAN 202: ENVIRONMENTAL CHEMISTRY/FUNDAMENTALS OF
ENVIRONMENTAL CHEMISTRY

DATE:

TIME: 2 Hrs

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks).

QUESTION ONE COMPULSORY (30 MARKS)

- (a) The atmosphere can be divided into distinct regions based on the temperature – altitude profile.
- i. Using the horizontal axis to represent temperature in K and the vertical scale to represent the altitude in km, sketch the temperature- altitude profile demarcating clearly the various regions. **(4 marks)**
 - ii. Account for the variation in temperature at various regions. **(2 marks)**

- iii. Describe briefly the tropo-chemistry that occurs in the troposphere accounting for the source of $\cdot\text{OH}$ free radicals responsible for the reactions therein. (2 marks)
 - iv. Explain how ozone (O_3) is formed and depleted (natural control) to maintain a steady state in the stratosphere. (2 marks)
 - v. why is the depletion of ozone an environmental concern to mankind? (2 marks)
 - vi. Explain the NO_x catalytic chain in ozone depletion. (2 marks)
 - vii. what are chlorofluorocarbons (CFC)? (2 marks)
 - viii. Why are CFCs of environmental concern to mankind? (2 marks)
- (b) Due to urban air pollution by transportation, there has been an attempt to eliminate the exhaust gases, NO_x , CO and volatile hydrocarbons and the liquid fuels used in transport have substantially been changed especially the composition of gasoline.
- i. Explain how these gases have been eliminated from the exhaust gases through a three- way catalytic converter. (3 marks)
 - ii. Explain knocking and octane rating (3 marks)
 - iii. Explain how the antiknock agent is used to control knocking (3 marks)
 - iv. Explain the major improvements on the gasoline that has ensured pollution resulting from the use of the antiknock agent mentioned in b(iii) has been eliminated. (3 marks)

QUESTION TWO (20 MARKS)

- (a) The atmosphere is continuously in exchange of its constituents with the other segments of the environment (hydrosphere, biosphere and lithosphere) through cycles. Consequently, the components of the atmosphere are said to be at steady state condition.
- i. What is the steady state condition? (1 mark)
 - ii. State two parameters which describe what the atmosphere exchanges with Earth's surface through the cycles mentioned above. (1 mark)
 - iii. Describe when the steady state condition of components of the atmosphere is achieved in terms of inputs and outs. (2 marks)
 - iv. Describe what is the source and sink of the components of the atmosphere. (2 marks)

- v. Describe in details how any component of the atmosphere can result in accumulation and depletion. (2 marks)
- (c) The atmosphere is known to derive its components mentioned in 2(a) through cycles.
- Briefly describe 3 sources which the atmosphere receives its constituents described in 2(a). (3 marks)
 - Describe in details how the entry of these components into the atmosphere through the troposphere is regulated. (2 marks)
- (d) The energy received by the Earth from the sun is governed by the equation, $E_E = E_A$, where $E_A = (1-A)F$, where E_E is the energy emitted by the Earth and E_A is the energy absorbed by the Earth. Explain what A whose value is 0.29 and F whose value is 1370 W m^{-2} represent, respectively. (1 mark)
- (e) The energy E_E is the Earth's electromagnetic radiation (emitted as a black body radiation) where $E_E = 4\pi R^2 \sigma T^4$
 Where R = radius of the planet
 $\sigma = 5.67 \times 10^{-8} \text{ Wm}^{-2}$
 T = Temperature of the Earth.
 The solar radiation is absorbed by a disk with an area πR^2 perpendicular to the solar radiation. Therefore, $\pi R^2 (1-A)F = 4 \pi R^2 \sigma T^4$
- From the above expression, make T^4 the subject of the equation. (1 mark)
 - Express the equation in (i) in terms of T. (1 mark)
 - Calculate the value of T. (1 mark)
- (f) The value obtained in d (iii) is 256K which is the temperature expressed in Kelvin
- Express the value above in centigrade ($^{\circ}\text{C}$). (1 mark)
 - The temperature of the earth is normally 298K, Explain this difference between the calculated value and the actual value. (2 marks)

QUESTION THREE (20 MARKS)

- (a) The following Table 3.1 shows the Greenhouse efficiency of various key gases.

Table 3.1. Greenhouse efficiency of key gases

Component	Greenhouse efficiency per molecule
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CO ₂	1
CH ₄	21
N ₂ O	206
CFC-11	12400
CFC-12	15800

- i. Explain why both O₂ and N₂ are not included as greenhouse gases. (2 marks)
 - ii. Explain why despite CO₂ is the least efficient as a greenhouse gas, is said to be one of the most contributing to global warming. (2 marks)
 - iii. Explain the term greenhouse effect. (2 marks)
- (b) Stratospheric ozone is said to be a protective layer for mankind against the UV radiation from the sun.
- i. Describe how ozone (O₃) is made and converted to O₂ in the stratosphere to maintain a steady state in order to provide a protective layer to the Earth. (2 marks)
 - ii. Explain how the reaction in 3b(i) is upset leading to ozone layer depletion. (2 marks)
- (c) The atmospheric pollution has led to the generation of both industrial and photochemical smog.
- i. Define photochemical smog and explain how it is formed. (2 marks)
 - ii. Describe how industrial smog is formed. (2 marks)
- (d) Due to urban air pollution by transportation, there has been an attempt to eliminate the exhaust gases, NO_x, CO and volatile hydrocarbons, and the liquid fuels used in transport have substantially been changed especially the composition of gasoline.
- i. Explain how these gases have been eliminated from the exhaust gases through a three-way catalytic converter. (2 marks)
 - ii. Explain knocking and octane rating. (1 mark)
 - iii. Explain how the antiknock agent is used to control knocking. (1 mark)
 - iv. Explain the major improvements on the gasoline that has ensured pollution resulting from the use of the antiknock agent mentioned in c(iii) has been eliminated. (2 marks)

QUESTION FOUR (20 MARKS)

- (a) Describe with examples what are non-renewable energy sources (3 marks)
- (b) Explain in details the effects of the non-renewable energy on the various segments of the environment. (4 marks)
- (c) The solution to the environmental problems caused by use of the non-renewable energy sources is replacing them with renewable energy sources. Describe how solar energy is a renewable energy source and how it can be harnessed to provide clean energy source. (3 marks)
- (d) Hydrogen gas is now regarded as the renewable energy that can drive modern economies.
- i. With the help of a diagram and appropriate chemical equations, describe how H_2 can be generated from the electrolysis of water. (5 marks)
 - ii. Describe with the help of a diagram how the H_2 Fuel cell can generate clean and non-polluting energy to be utilized in the various sectors of the modern economies. (5 marks)

QUESTION FIVE (20 MARKS)

- (a) Water is expected to have a pH of 7. However, the pH of rain water can be lowered to the range of 5-3.5 in polluted areas.
- i. What are the three prominent acidic constituents that can lead to acid rain? (1½ marks)
 - ii. Describe how the pH of rainwater initially at 5.7 at the top soil varies down the soil profile. (1½ marks)
 - iii. Describe briefly the effects of acid rain to soil and the aquatic environment. (3 marks)
- (b)
- i. What is biological oxygen demand and how is it a measure of organic pollution of a water system? (2 marks)
 - ii. Describe how Eutrophication occurs in fresh water lakes. (2 marks)
 - iii. Differentiate between non-point sources of pollution and point source of pollution. (2 marks)
- (c) Agricultural chemicals are applied to the soil for both improved fertility and prevention of pests to boost food production.

- i. differentiate between organic fertilizer and inorganic fertilizer. (2 marks)
- ii. State advantages of organic fertilizer over that of inorganic fertilizer. (3 marks)
- iii. Discuss briefly the differences between the organochlorines and organophosphates. (3 marks)