MACHAKOS UNIVERSITY

University Examinations for 2021/2022 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

SECOND YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ANALYTICAL CHEMISTRY)

SAN 202: FUNDAMENTALS OF ENVIRONMENTAL CHEMISTRY

DATE: 9/12/2021 **TIME: 11.00-1.00 PM**

INSTRUCTIONS:

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

Required Data

$h = 6.63x10^{-34}$ j.s
$c = 3X10^{8}$ m/s

NA = Avogadro's number = $6.02x10^{23}$

SECTION A – 30 MARKS - COMPULSORY

QUESTION ONE (30 MARKS)

a) Differentiate between the following terms

i. Green Chemistry and Environmental Chemistry. (2 marks)

ii. Contaminant and pollutant. (2 marks)

b) Briefly describe:

i. The Gaia hypothesis. (2 marks)

ii. The formation of photochemical smog using relevant equations. (4 marks)

c) List three (3) anthropological activities that are partly responsible for changing the meteorology of the earth. (3 marks)

d) Explain the following environmental chemistry statements.

i. The availability of light with sufficient photon energy is necessary, but not a sufficient condition for reaction to occur with any given molecule. (2 marks)

ii. Rapidly developing new technologies, of which transgenic biotechnology is a prime example, is the emergence of problems, often related to public concern, that were unforeseen in the development of the technologies. In order to avoid such problems, increasing use is being made of scenario creation. (2 marks)

e) Draw and explain the major regions of the atmosphere with temperature, pressure, altitude and ozone concentration profile. (4 marks)

f) Resistance to biodegradation is known as recalcitrance. List three (3) factors that can cause recalcitrance. (3 marks)

g) Fish have been dying in a river downstream from a company which makes batteries. The public is outraged, and a local news reporter is publishing articles blaming the industry, saying that dissolved mercury from their discharge pipe must be causing the fish to die. If you were sent in as an impartial investigator,

i. State one question that you would want to find answers to. (1 mark)

ii. List samples that you would take (how, when, where, how frequently?) (3 marks)

iii. What analyses would you do on these samples? (2 marks)

SECTION B: ANSWER ANY TWO QUESTIONS - 20 MARKS EACH

QUESTION TWO (20 MARKS)

a) Using specific example, briefly explain the following terms.

i. Earth's radiation balance (2 marks)

ii. Enhanced greenhouse effect. (2 marks)

b) The chemistry of ozone depletion and of many other processes in the stratosphere is driven by energy associated with light from the sun. Briefly explain;

i. The ozone location and abundance in the atmosphere. (2 marks)

ii. The formation of both stratospheric and tropospheric ozone. (4 marks)

iii. Using specific examples, discuss in details the statement, 'among all halogens, bromine is the most effective ozone killer. (5 marks)

c) Ozone is highly unstable relative to O_2. Consider the following 4-step mechanism and reaction rates for the production and destruction of ozone in the atmosphere

$O_2 \longrightarrow O + O$/ Reaction rate = $k_1(O_2)$

$O + O_2 + M \longrightarrow O_3 + M$/ Reaction rate =$k_2(O)(O_2)(M)$

$O_3 \longrightarrow O + O_2$/ Reaction rate = $k_3(O_3)$

$O + O_3 \longrightarrow O_2 + O_2$/ Reaction rate = $k_4(O)(O_3)$

Develop an expression for the steady-state concentration of O_3/O_2. (5 marks)

QUESTION THREE (20 MARKS)

a) In Kenya, for example, Turkana County and parts of Kitui region are short of freshwater for drinking. One possible though ridiculous solution to the problem is to tow icebergs from Antarctica and then melt them as needed as represented in this equation: $H_2O(s) \rightarrow H_2O(l)$. If ΔH is 7.05 kJ/mol for the reaction at 0°C and constant pressure, how much energy in joules would be required to melt a moderately large iceberg with a mass of 2.00×10^6 metric tons)? (A metric ton is 1000 kg). (4 marks)

b) Cycles of matter are called biogeochemical cycles, because they include both biotic and abiotic components and processes. Using a relevant diagram, discuss the sulfur cycle. (6 marks)

c) Briefly discuss:

i. Four physical and chemical properties that dictate the fate of organic contaminants in the environment. (6 marks)

ii. With relevant examples, co-metabolism and detoxification as viable mechanisms of microbial degradation and transformation of organic contaminants. (4 marks)

QUESTION FOUR (20 MARKS)

a) Write reactions for formation of;

i. $Fe_2O_3.3H_2O$. (2 marks)

ii. C_2H_5OH. (2 marks)

b) Write the reaction for which the enthalpy change will be standard enthalpy of combustion for;

i. C_3H_8 (2 marks)

ii. C_3H_7OH (2 marks)

c) What is the enthalpy change for the reaction shown below using the enthalpies of formation listed; (4 marks)

NH_3 = -46KJ/mol; NO_2 = +34KJ/mol; H_2O = -286 KJ/mol

$$4NH_3 + 7O_2 \longrightarrow 4NO_2 + 6H_2O$$

d) Briefly explain;

i. Two uses of trifluoroacetic acid (TFA) (2 marks)

ii. Safety precautions employed when handling TFA. (2 marks)

iii. The advantages and limitations of replacing Chlorofluorocarbons (CFCs) with carbon dioxide. (4 marks)

QUESTION FIVE (20 MARKS)

a) Differentiate between the following terms

i. Grub sampling and composite sampling. (2 marks)

ii. Luminescence and photoionization. (2 marks)

b) Define the term free radical and using two relevant examples, discuss the reaction of free radicals in the atmosphere. (5 marks)

c) Sulfur dioxide is soluble in water, $K_H = 1.8 \times 10^{-5}$ mol L^{-1} Pa^{-1} at 25°C. Calculate the equilibrium aqueous concentration of SO_2 in raindrops, if the air contains 2.0 ppmv of $SO_2(g)$.

i. Calculate the pH of this rain. (4 marks)

ii. How would your answer change if the dissolved sulfur dioxide is oxidized to sulfur trioxide? Justify your answer. (2 marks)

d) In the flue-gas desulfurization process, the removal of SO_2 using Calcium carbonate is represented by the following equation:

$CaCO_3 + SO_2 \rightarrow CaSO_3 + CO_2$ and $2CaSO_3 + O_2 \rightarrow 2\ CaSO_4$

Calculate the mass of calcium carbonate that is required to react with the sulfur dioxide produced by burning 1000 kg of coal that contains 5.0 % sulfur by mass. (5 marks)