MACHAKOS UNIVERSITY

University Examinations 2019/2020Academic year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN ANALYTICAL CHEMISTRY

SAN 202: FUNDAMENTALS OF ENVIRONMENTAL CHEMISTRY

DATE: 6/12/2019 **TIME: 8.30-10.30 AM**

INSTRUCTIONS TO CANDIDATES

- The paper consists of **two** sections.
- Section **A** is **compulsory**.
- Answer any **two** questions from section **B**.

Required Data

Planks constant h = $6.63x10^{-34}$ j.s
Speed of light c = $3X10^{8}$ m/s

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

SECTION A - COMPULSORY.

QUESTION ONE (30 MARKS)

a) Define each of the following terms as used in Environmental Chemistry;

i. Photochemical smog

ii. Sink

iii. Null cycle

iv. Global warming

v. Full spectrum as used in sunscreens. (5 marks)

b) Differentiate between the following terms

i) Troposphere and stratosphere. (2 marks)

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

iii) UV-A and UV-C. (2 marks)

c) Briefly describe:

i) Green house effect. (2 marks)

ii) The effect of carbon tetra chloride and methyl chloroform on ozone. Explain which one has a larger negative impact. (4 marks)

d) Deduce the balanced equation of the reaction between ammonia and nitrogen dioxide. (2 marks)

e) Explain the following environmental statements:

i) The ozone hole appeared over Antarctica yet ozone-depleting substances are present throughout the stratosphere. (2 marks)

ii) Ozone layer depletion increases the amount of ground level ultraviolet radiation. (2 marks)

iii) 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)

f) The ΔH° for the decomposition of ozone into O_2 and atomic oxygen is +105 KJ/mol. Calculate the longest wavelength of light that could dissociate ozone in this manner and indicate the region of the electromagnetic spectrum in which the wavelength falls. (3 marks)

g) By analogy between the reaction of O* with methane, write a balanced equation for the reaction by which O* produces OH from water vapor. (2 marks)

SECTION B: ANSWER ANY TWO QUESTIONS

QUESTION TWO (20 MARKS)

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

i. Define the term ozone. (1 mark)

ii. Briefly explain the ozone location and abundance in the atmosphere. (2 marks)

iii. Briefly explain the formation of both stratospheric and tropospheric ozone. (2 marks)

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

b) Determine the energy in kilojoules per mole associated with the following wavelengths and indicate the significance of each of the respective wavelengths.

i) 280 nm (2.5 marks)

ii) 4000 nm (2.5 marks)

c) Using the enthalpy of formation information given, calculate the maximum wavelength that can dissociate NO_2 to NO and atomic oxygen. Recalculate the wavelength if the reaction is to result in the complete dissociation into free atoms (i.e., N + 2O). Is light of these wavelengths available in sunlight? (5 marks)

ΔH_f° values (KJ/mol): NO_2: +33.2; NO: +90.2; N: +472.7; O: +249.2

QUESTION THREE (20 MARKS)

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

i) Chapman cycle. (2 marks)

ii) Nature's interest. (2 marks)

b) Consider the following 3-step mechanism for the production and destruction of exited oxygen atoms, O*, in the atmosphere

$$O_2 \longrightarrow O + O^*$$

$$O^* + M \longrightarrow O + M$$

$$O^* + H_2O \longrightarrow 2OH$$

Develop an expression for the steady-state concentration of O* in terms of the concentrations of the other chemicals involved (3 marks)

c) Explain the following statements

i) When a hand pump is used to inflate a bicycle tire, the bottom of the pump barrel can get quite warm. (2 marks)

ii) Its get cooler as one goes high up. (2 marks)

iii) Large bodies of water have a "moderating" effect on the local weather, reducing the extremes of temperature that occur in other areas. (2 marks)

d) Explain two uses of trifluoroacetic acid (TFA), safety precautions when handling TFA and explain it's environmental impacts. (7 marks)

QUESTION FOUR (20 MARKS)

a) Differentiate between the following terms

i) Albedo and blackbody (2 marks)

ii) Bending vibration and stretching vibration. (2 marks)

b) Deduce whether the following molecules will absorb infrared light due to internal vibrational motions or not.

i) CCl_4 (1 mark)

ii) CO (1 mark)

c) i Calculate the ratio of the rates of energy release by two otherwise identical blackbodies, one of which is at O°C and the other at 17°C.

ii Determine at what temperature is the rate of energy released twice that at 0°C. (5 marks)

d) Using relevant examples, describe in details the effects of pesticides in the environment. (9 marks)

QUESTION FIVE (20 MARKS)

a) An alkaline electrolyte can be used in the H_2-O_2 fuel cell to replace the acidic environment. Assuming that the reaction of O_2 with water and electrons produces hydroxide ions, and that these ions travel to other electrode, where they react with hydrogen to give up electrons and produce more water, deduce the two balanced half reactions and the balanced overall reaction for such a fuel cell. (3 marks)

b) The average outdoor concentration of carbon monoxide was found to be 1000 $\mu g/m^3$. Determine this concentration expressed on the:

i) The ppm scale

ii) The molecules per cm^3 scale, and

Assume that the outdoor temperature is 17°C and that the total air pressure is 1.04 atm.

(5 marks)

c) Given that the concentration of CH_4 in the atmosphere is 1.8 ppm, calculate the total mass of this gas that is present in the atmosphere. Note that the mass of the atmosphere = 5.1 x 10^{21} g, and that air's average molar mass = 29.0 g mol^{-1}. (5 marks)

d) Explain why the vertical transport in the atmosphere is not affected by the fact that the mass of such molecules is greater than the average molecular mass of nitrogen and oxygen in air. (2 marks)

e) Briefly explain the advantages and limitations of replacing Chlorofluorocarbons (CFCs) with carbon dioxide. (5 marks)