MACHAKOS UNIVERSITY

University Examinations for 2021/2022 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

.....YEAR ..... SEMESTER EXAMINATION FOR

MASTER OF SCIENCE (CHEMISTRY)

SCH 811: ENVIRONMENTAL CHEMISTRY

DATE: **TIME:**

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 = Planck's constant = 6.624×10^{-34} J s
c = velocity of light = 3×10^{10} cm/s
NA = Avogadro's number = 6.02×10^{23}

SECTION A-COMPULSORY 30 MARKS

QUESTION ONE (30 MARKS)

a) Briefly explain;

i. Why vertical mixing of air is not a prevalent phenomenon in the stratosphere. (2 marks)

ii. The phrase ozone layer is a misnomer. (2 marks)

iii. How internal combustion engines can be modified to make auto-exhausts free from pollutants. (2 marks)

b) Draw and explain a well labelled diagram to represent the vertical structure of the atmosphere and associated temperature and pressure variation. (5 marks)

c) Hydrogen sulfide (H_2S) and SO_2 coexist in the atmosphere. Describe the UV molecular absorption method for the determination of H_2S. (5 marks)

d) Anthropogenic carbon dioxide emissions into the atmosphere amounted to 178 Gt from January 1990 to December 1997. Calculate the fraction of this emitted carbon dioxide that remained in the air, given that in the same eight-year period, the carbon dioxide concentration in air rose by 11.1 ppm. Note that the molar masses of C, O, and air, respectively, are 12.0, 16.0, and 29.0 g, and that the mass of the atmosphere is 5.1×10^{21} g, and that 1 Gt is 10^{15} g. (4 marks)

e) A proposed mechanism for ozone destruction in the late spring over northern latitudes in the lower stratosphere begins with the photochemical decomposition of $ClONO_2$ and NO_3, followed by photochemical decomposition of the latter to NO and O_2. Deduce a catalytic ozone destruction cycle requiring no atomic oxygen, that incorporates these reactions and state it's corresponding overall reaction. (5 marks)

f) Calculate the energy, in kilojoules per mole, associated with photons having the following wavelength and state the significance of each of these wavelengths.

i. 400 nm. (2.5 marks)

ii. 4000 nm. (2.5 marks)

SECTION B- ANSWER ONLY TWO QUESTIONS (15 MARKS EACH)

QUESTION TWO (20 MARKS)

a) The vapor pressure P of a liquid rises exponentially when it is heated according to the equation $\ln(P_2/P_1) = -\Delta H/R\ (1/T_2 - 1/T_1)$. P_1 and P_2 are the vapor pressures of the liquid at the Kelvin temperatures T_1 and T_2 after and before the temperature increase, R is the gas constant, and ΔH is the liquid's enthalpy of vaporization, which for water is 44 kJ/mol.

i. Calculate the percentage increase in the vapor pressure of water that occurs if the temperature is raised from 15ºC to 18ºC. (3 marks)

ii. State two reasons why the amount of outgoing thermal infrared in water's absorption bands may not be increased by exactly the percentage you have calculated if the average air/surface temperature is increased to 18ºC. (2 marks)

b) 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)

c) Giving a brief explanation, propose a viable method to control;

i. CO emission. (2.5 marks)

ii. Particulate emission. (2.5 marks)

QUESTION THREE (20 MARKS)

a) Elucidate this statement, 'oxygen plays a key role in the troposphere, while ozone plays a key role in the stratosphere." (3 marks)

b) Write out the two-step mechanism by which the hydroxyl free radical catalytically destroys ozone and deduce the overall reaction. (3 marks)

c) Explain why;

i. Atom for atom stratospheric bromine destroys more ozone than does chlorine. (2 marks)

ii. Ozone destruction via the reaction of O_3 with atomic oxygen does not occur to a significant extent in the lower stratosphere. (2 marks)

d) Atomic chlorine is produced under ozone-hole conditions by the dissociation of diatomic chlorine. Given that diatomic chlorine has the most stable form of the element and $\Delta H^ºf$ value for atomic chlorine is +121.7 kJ/mol;

i. Calculate the maximum wavelength of light that can dissociate diatomic chlorine into the monoatomic form. (4 marks)

ii. Does such a wavelength correspond to light in the visible or the UV-A or the UV-B region? (1 mark)

QUESTION FOUR (20 MARKS)

a) Briefly explain the following terms as used in environmental air pollution.

i. Cold trapping. (2 marks)

ii. Absorption. (1 mark)

iii. Adsorption. (1 mark)

b) Using the enthalpy of formation information given below, ΔHf^{o} values (kJ/mol): NO_2: +33.2; NO: +90.2; N: +472.7; O: +249.2

i. Calculate the maximum wavelength that can dissociate NO_2 to NO and atomic oxygen. (2 marks)

ii. Recalculate the wavelength if the reaction is to result in the complete dissociation into free atoms. Is light of these wavelengths available in sunlight? (3 marks)

c) Using one relevant example.

i. Explain a primary air pollutant. (1 mark)

ii. Discuss, it's source and relative contribution to air pollution. (4 marks)

QUESTION FIVE (20 MARKS)

a) Explain the following terms as used in environmental Chemistry

i. Environmental Impact assessment. (2 marks)

ii. Scoping. (1 mark)

b) Nairobi being the capital city of Kenya continues to attract and accommodate most of the mega real estate developments. Amalia Properties Limited has proposed to develop 29 No of Floors apartments on plot L.R. No. 209/18650 Kiambu Road- Karura Forest Nairobi County. The development will comprise a total of 290 units.

i. List the four main steps in the process of carrying out effective environmental impact assessment. (2 marks)

ii. Discuss in details both the potential positive and negative impacts that may be associated with this project. (10 marks)