CHU 3122- Environmental Chemistry- 2008/2009
Study questions

1. (a)(i) What are the three major constituents of the atmosphere?
(ii) Identifying the relevant chemical species/components, write down the main functions of the atmosphere.
(iii) Sketch the variation, with altitude, of air temperature for various regions of the atmosphere up to 500 km.

(b) The four major regions of the atmosphere are characterized by the altitude from the Earth's surface, temperature range and the major chemical species present.
(i) Draw a diagram to show the four major regions in the atmosphere.
(ii) Identify, in the diagram, the four major regions and indicate the important characteristics of these regions

2.(a)(i) What are the two major anthropogenic sources of SO_2 in the atmosphere?
(ii) Describe, using equations, the processes that lead to acid rain.
(iii) What are the adverse effects of acid rain on the environment?
(iv) A certain lake has a volume of 1.5×10^6 m^3. Its pH has dropped to 4.65 and all the fish are dead. Before restocking it, you need to re- adjust the pH back to 5.50 by spraying the lake with powdered $CaCO_3$. The relevant reaction is:
$H^+ + CO_3^{2-} \rightarrow HCO_3^-$. How much $CaCO_3$ would you need?
(Assume that the acidity of the lake is due to free H^+, i.e., you need not worry about any weak acid present that may act as buffers)

(b) Calculate the pH of rain water in equilibrium with 0.50 ppmv (0.5×10^{-4} %) of gaseous SO_2 in the atmosphere. Assume a total pressure of 1.00 atm and a temperature of 25^{0}C. The following data are given for this temperature. Remember that H_2SO_3(aq) is equivalent to SO_2(aq): The dissociation of HSO_3^- is negligible. Henry's Law constant K_H for SO_2in water is 1.2 mol $dm^{-3}atm^{-1}$; K_a for $H_2SO_3(aq) \rightleftharpoons H^+(aq) + HSO_3^-(aq)$ is 1.7×10^{-2} moldm^{-3}.
(Hint: Assume no contribution from other acidic gases present).

3.(a)(i) What are freons? How do they adversely affect the environment? Give equations to supplement your answer.
(ii) Ozone Depletion Potential (ODP) of CFC and related compounds are compiled to express the likelihood of destruction of stratospheric ozone. Explain why the ODP of $CHFCl_2$ (0.40) is lower than that of $CFCl_3$ (1.0).
(iii) What is the role of ozone in the stratosphere? How does it behave in the troposphere?

(b)(i) Write down a stepwise mechanism for the destruction of ozone by chlorofluorocarbons (CFC) in the stratosphere. Briefly indicate the climatic and health related problems posed by a significant depletion of O_3 in the stratosphere.

(ii) The table below gives the C-X bond energies for a series of molecules CF_3X, where X is Cl, Br and I.

X	Bond energy (kJmol^{-1})
Cl	360
Br	295
I	224

Calculate the maximum wavelength (in nm) of light capable of photolysing each of the above

mentioned bonds. Based on the calculation in (i), explain why iodofluorocarbons pose no hazard to stratospheric ozone.
(Planck's constant, $h = 6.626 \times 10^{-34}$ Js; speed of light, $c = 3 \times 10^{8}$ ms^{-1}; Avogadro's number, $N_A = 6.023 \times 10^{23}$ mol^{-1}).

4.(a)(i) What is meant by the term 'smog'? What are the chemical components of sulphurous smog and photochemical smog? What are the physical characteristics of photochemical smog?
(ii) List four conditions essential to the formation of photochemical smog. Describe, using equations, the process of formation of photochemical smog. Write a short account of the harmful effects of photochemical effects.

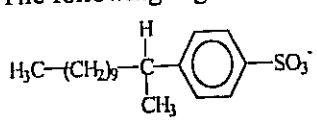
(b)(i) Define the words "source" and "sink" as used in environmental chemistry. Name three important sources of CH_4 in the atmosphere. What is the major sink of CH_4 in the troposphere?
(ii) The concentration of CH_4 in the atmosphere has increased significantly over the last 200 years or so. Discuss the reasons for this and predict the possible impact on the environment.

(c)(i) List four toxic metals in the atmosphere and their sources. Briefly describe the health effects of particulate matter.
(ii) Formaldehyde, HCHO is an important toxic trace component of both the outdoor and the indoor atmosphere. Briefly describe how formaldehyde is formed in the 'normal' outdoor atmosphere. Briefly discuss the various sources of formaldehyde in the indoor atmosphere.

5.(a)(i) Write down the three main physical properties of a water body that affect aquatic life.
(ii) Briefly explain how they affect aquatic life.

(b)(i) Define the terms 'Total alkalinity' and 'BOD'.
(ii) The concentration of O_2 in water at equilibrium with pure gaseous O_2 at a pressure of 1.00 atmosphere is 1.3×10^{-3} $mol.dm^{-3}$ at 25^0C. What is the concentration of O_2 dissolved in water at equilibrium with air at the same temperature? (partial pressure of $O_2 = 0.21$ atm.)

(c) The following organic anion is found in most detergents:



Assume that the anion undergoes aerobic decomposition in the following manner:

$$2C_{18}H_{29}SO_3^-(aq) + 51O_2(aq) \rightarrow 36CO_2(aq) + 28\,H_2O(l) + 2H^+(aq) + 2SO_4^{2-}(aq)$$

(i) What is the total mass of O_2 required to biodegrade 1.0g of this substance?
(C=12, H=1, S=32, O=16)
(ii) If 1.250kg of this detergent is accidentally discharged into a small stream saturated with oxygen from the air at 25^0C, how many dm^3 of this water could be contaminated to the extent of removing all the dissolved oxygen by biodegradation?

(d)(i) Write down the unique properties of water and explain their effects on life.
(ii) Explain how 'productivity' is related to water quality.
(iii) Briefly discuss the sources, sinks and the environmental effects of the pollutant trace elements in water.
(iv) List **four** each of metal ions and ligands that may be present in a wastewater system. Indicate their sources in industry.

(e)(i) Write down the mathematical expression for the Henry's Law and identify the terms in it.