CMU 3129- Environmental Chemistry

Study questions

1) a) (i) Draw a diagram to show the four major regions and boundaries (pauses) in the atmosphere.

(ii) Differentiate the regions according to their important characteristics (i.e. altitude from the Earth's surface, temperature range and the major chemical species present)

(iii) Explain giving reasons the temperature variation in these regions.

b) (i) What are the major constituents of the atmosphere?

(ii) What is meant by greenhouse effect? How do certain chemicals contribute to this effect?

(iii) List two naturally occurring constituents of the atmosphere that contribute to this effect.

(iv) The major constituents of the atmosphere do not contribute to the greenhouse effect. Explain.

2) a) Define the following terms used in environmental chemistry.

(i) Pollutant	(ii) Contaminant	(iii) Source
(iv) Receptor	(v) Sink	(iv) Residence time

b) Ozone is an important oxygen containing species found in the stratosphere.

(i) Briefly describe the biological significance of stratospheric oxygen at the Earth's surface.

(ii) How is O_3 produced in the stratosphere?

(iii) Describe the mechanism(s) by which O_3 is depleted in the stratosphere.

(iv) In the atmosphere above a particular city, at normal atmospheric pressure and a temperature of 27^0C, the partial pressure of O_3 is determined to be 4.9×10^{-5} mm Hg. Calculate the concentration of O_3 in the atmosphere, in parts per billion ($\mu g\ dm^{-3}$).

Assume that 1 atmosphere = 760 mm Hg = 1×10^5 Pa; R = 8.314 J mol^{-1} K^{-1}.

c) (i) What is meant by 'acid rain'?

(ii) What are the main anthropogenic sources of acid rain?

(iii) Write the adverse effects of acid rain?

d) (i) Briefly discuss the origin of various inorganic and organic particulates in the atmosphere.

(ii) Write a short account of the various radio nuclides present in the environment with special reference to their origin.

3) (a)(i) Write down four of the unique properties of water. What are their effects on life?

(ii) What do you mean by the term 'productivity' of a water body? Briefly explain how it is related to water quality.

(iii) Briefly discuss the sources, sinks and the environmental effects of the pollutant trace elements in water.

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

(ii) It has been suggested that the atmospheric carbon dioxide may reach 600 ppmv (0.060% v/v) with in a century. What would be the pH of rain water in equilibrium with 600 ppmv of $CO_2(g)$?

(Henry's Law constant for CO_2 in water is 3.38×10^{-2} mol $dm^{-3} atm^{-1}$; the vapour pressure of water at 25^0C is 0.0313 atm.; equilibrium constant K_1 for:

$CO_2 + H_2O == H^+ + HCO_3^-$ is 4.45×10^{-7} mol dm^{-3})

(c) (i) You are given the pE^0 value for the following redox reactions:

$\frac{1}{4} O_2(g) + H^+(aq) + e^- == \frac{1}{2} H_2O$ $\qquad pE^0 = 20.75$

$\frac{1}{8} SO_4^{2-}(aq) + \frac{5}{4} H^+(aq) + e^- == \frac{1}{8} H_2S(g) + \frac{1}{2} H_2O$ $\qquad pE^0 = 5.25.$

Estimate pE value for the aquatic habitat characterized by the following analytical information:

(α) Water from the deeper layers of a lake having dissolved O_2 with a partial pressure of 6×10^{-4} atmosphere and a pH of 7.0 at 25^0C.

(β) A water sample of pH=6 containing $[SO_4^{2-}]=10^{-3}$ mol dm^{-3} and smelling of H_2S ($P_{H_2S}=10^{-2}$atm).

(ii) Explain briefly the phenomenon 'thermal stratification'. How does pE vary with depth in a stratified lake? Explain.

4) (a)(i) Write down the three main physical properties of a water body that affect aquatic life.

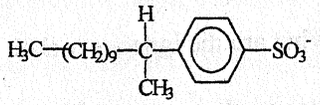
(ii) Briefly explain how they affect aquatic life.

(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 atm is $1.3x10^{-3}$ $mol.dm^{-3}$ 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 1.360kg 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?

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

© (i) What is ment by the term 'smog'? What are the chemicals components of sulphurous smog and photochemical smog? What are the physical characteristic of photochemical smog?

(ii) List four conditions essential to the formation of photochemical smog? Describe, using equations, the process of formation photochemical smog. Write a short account of the harmful effects of photochemical effects.

6. 1. a. (i) What are the functions of soil.

(ii) Discuss the importance of soil organisms to maintain the quality of soil.

(iii) What is meant by soil profile? Discuss the characteristic features.

(iv) What do you mean by texture and structure of soil.

b. (i) What are the soil forming rocks?

(ii) What are the igneous rocks?

c. (i) Discuss the process of formation of soil.

(ii) Explain the transformations occurring in physical and chemical weathering of rocks?

d. (i) Discuss the role of clay matter to control the property of soil.

e. (i) How are solid wastes classified?

(ii) Discuss the advantages and disadvantages of incineration process of solid waste.

(iv) Discuss the different phases of waste degradation in a landfill.