

The Open University of Sri Lanka

B.Sc. Degree Programme – 2011/2012

Environmental Chemistry - CMU 3129

Duration 2 hours

MODEL PAPER

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Date: \*\*\*\*\*

Time: \*\*\*\*\*

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NOTE: Final Examination on Environmental Chemistry (CMU 3129) – 2011/2012 will be based on Unit I (Environmental Chemistry of the Atmosphere) and Unit II (Environmental Aquatic Chemistry).

Answer any four (04) Questions

1. a. According to variation of temperature with altitude, the atmosphere is divided into four major strata (layers), the characteristics of which differ widely. The two strata closer to the surface Earth surface show considerable chemical and photochemical reactivity.
- Identify the two strata closer to the Earth's surface.
  - Describing the variation of temperature within these strata, sketch the temperature profile of these two strata. Indicate the characteristic of these strata.
  - Write the major phenomenon(on/a) that is /are associated with each of these strata.
- (70 marks)
- b. i. Write two important sources of  $\text{CH}_4$ . What is the environmental consequence of increased levels of methane in the atmosphere?
- Briefly describe the major sink of  $\text{CH}_4$  in the atmosphere.
- (30 marks)
2. a. We all know that the atmosphere contains 78% nitrogen by volume; it is an inexhaustible reservoir of that essential element. Atmospheric nitrogen is fixed and subsequently returned to the atmosphere as gaseous molecular nitrogen in the nitrogen cycle.
- Draw the nitrogen cycle.
  - Explain the terms atmospheric fixation, biological fixation and industrial fixation of nitrogen.
- (40 marks)

b. Greenhouse gases are responsible for keeping our planet warm and thus sustaining life on Earth. Carbon dioxide and water vapour are such gases.

i. Briefly explain, with an example, the difference between the “anthropogenic greenhouse effect” and the natural greenhouse effect’.

ii. Why does the term ‘greenhouse effect’ not mean the same as global warming?

(20 marks)

c. i. What do you understand by the term ‘alkalinity’ of a water sample?

ii. Give three major species that are responsible for the alkalinity in water.

iii. Calculate the total alkalinity for a sample of a river whose phenolphthalein alkalinity is known to be  $3.0 \times 10^{-5} \text{ mol dm}^{-3}$ , whose pH is 10.0 and bicarbonate ion concentration is  $1.0 \times 10^{-4} \text{ mol dm}^{-3}$ .

(40 marks)

3.a. When the atmosphere is loaded with quantities of automobile exhausts during warm sunny days with gentle winds and low level inversion, the exhaust gases are trapped and simultaneously exposed to intense sunlight. Then a series of photochemical reactions takes place giving rise to the phenomenon of ‘photochemical smog’.

i. Name the vehicle exhausts

ii. What are the components that contribute to photochemical smog?

iii. Write the physical characteristics of photochemical smog.

iv. Briefly describe the effects of photochemical oxidants on humans, plants and materials.

(50 marks)

b. i. Write down four unique properties of water.

ii. What is the effect of each of these properties on life?

(20 marks)

c. i. What is meant by the term “Dissolved Oxygen”(DO)?

ii. What is the importance of (DO)?

iii. Fish need at least 5 ppm dissolved  $\text{O}_2$  for survival.

(α) What is this concentration in  $\text{mol/dm}^3$ ?

(β) What partial pressure of  $\text{O}_2$  above the water is needed to obtain this concentration at  $25^\circ\text{C}$ ? (The Henry’s law constant for  $\text{O}_2$  at  $25^\circ\text{C}$  is  $1.3 \text{ mol dm}^{-3} \text{ Pa}^{-1}$ )

(30 marks)

- 4.a. i. What is meant by acid rain?  
 ii. What are the anthropogenic sources of acid rain?  
 iii. Briefly describe the effects of acid rain on materials.  
 iv. The concentration of  $Al^{3+}$  in natural waters normally is quite small; however it increases in the presence of acids.
- (c) What is the adverse effect of high concentration of  $Al^{3+}$  on fish?  
 (β) By what factor will the concentration of  $Al^{3+}$  increase when pH decreased from 5 to 4?

(50 marks)

- b. i. What is meant by the pE of an aqueous solution?  
 ii. What does a low pE value imply about a solution?  
 iii. Consider the reduction of nitrate ion in an acidic aqueous to ammonium ion.
1. Write a balanced equation for the **one electron half reaction** for the process.
  2. Given that for this reaction,  $E^0 = 0.880$  volts, calculate pE<sup>0</sup>.
  3. Deduce a relationship of pE to pE<sup>0</sup> for the above half reaction.
  4. From expression in part (3), obtain an equation relating the pE to pH under conditions in which the concentration of  $NO_3^- = NO_2^-$ .
  5. What will be the pE under condition of pH = 5?

(50 marks)

5. a. Stratospheric ozone is regarded as beneficial to mankind and chlorofluorocarbons (CFC) form a group of compounds responsible for depletion of ozone layer. For the first time in the history of mankind, the world acted fast to agree to phase them out completely. Alternative fluorocarbons were produced as good substitutes for CFC.

- i. What is the source of stratospheric ozone? Briefly describe its beneficial role.
- ii. Write equations to show how CFCs catalyse destruction of ozone. Name two other species that could catalyse this reaction.
- iii. Identify the protocol signed.
- iv. What problem(s) do you foresee that these fluorocarbons would pose?

(40 marks)

- b. i. Write the anthropogenic sources of the pollutants,  $SO_2$ ,  $NO_x$ , CO and  $O_3$ .  
 ii. Distinguishing between primary air pollutants and secondary air pollutants. Identify them from these pollutants.

(20 marks)

- c. i. What is meant by 'thermal stratification'?
- ii. Draw a labelled diagram to illustrate stratification of a lake in the summer, showing the typical forms of the main elements.
- (20 marks)
- d. i. What do you mean by the term 'Productivity' of a water body?
- ii. Briefly explain how it is related to water quality.
- (20 marks)
6. a. Describe the process of eutrophication?
- (10 marks)
- b. i. What is hard water?
- (ii) Differentiate between temporary and permanent hardness.
- (iii) Permanent hardness can be removed by adding washing soda,  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ , to the water to precipitate calcium carbonate which can then be removed by filtration. Calculate the mass of washing soda required to soften 1000 litres of hard water containing  $250 \text{ mg L}^{-1} \text{ Ca}^{2+}$ .
- (Relative atomic mass: Na = 23 , C = 12 , O = 16 , H = 1 )
- (40 marks)
- c. List four metal ions that may be present in a waste water system. Indicate their sources in industry.
- (20 marks)
- d. (i) In a water treatment process filter alum  $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$  is used as a coagulant. What does this process/reaction remove from water?
- (ii) Write equations to show its action during the process
- (30 marks)