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THE OPEN UNIVERSITY OF SRI LANKA

B.Sc/ B.Ed DEGREE PROGRAMME/ STAND ALONE COURSES IN SCIENCE

FINAL EXAMINATION- LEVEL 5- 2007/2008

CHU 3122/ CHE 5122- ENVIRONMENTAL CHEMISTRY

(2 ½ hours)

Saturday 5th January 2008

1.00 p.m.- 3.30 p.m.

ANSWER ANY FOUR QUESTIONS.

IF MORE THAN FOUR QUESTIONS ARE ANSWERED, ONLY THE FIRST FOUR ANSWERS WILL BE MARKED.

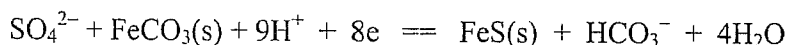
1. (a) According to variation of temperature with altitude, the atmosphere is divided into four major strata (layers), the characteristics of which differ widely. The two strata closer to the Earth surface show considerable chemical and photochemical reactivity.
- (i) Identify the two strata closer to the Earth's surface.
 - (ii) Describing the variation of temperature within these strata, sketch the temperature profile of these two strata. Indicate the characteristics of these strata.
 - (iii) Write the major phenom(en/a) that is/are associated with each of these strata. (70 marks)
- (b)(i) Write two important sources of CH₄. What is the environmental consequence of increased levels of methane in the atmosphere?
- (ii) Briefly describe the major sink of CH₄ 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.
- (i) Draw the nitrogen cycle.
 - (ii) Explain the terms atmospheric fixation, biological fixation and industrial fixation of nitrogen. (50 marks)

- (b)(i) Define the terms 'source' and 'sink' as applied to environmental chemistry.
(ii) Write the sources and sinks of atmospheric carbon dioxide. (20 marks)
- (c) 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 in each case, 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? (30 marks)
3. (a) Acid rain represents one of the major consequences of air pollution, because of large scale emissions from big industrial areas into the atmosphere.
- (i) What is meant by acid deposition?
(ii) Briefly discuss its causes and effects.
(iii) Using chemical equations, explain how acid rain can be neutralized by limestone. (30 marks)
- (b) Among the air pollutants that caused significant damage to the environment are the Freons which were used in a number of household products as refrigerants and aerosol formants in spray cans. After it was found that they catalyse the destruction of stratospheric ozone, their use was completely phased out.
- (i) What physical property/ies of Freons made them so useful in these household products?
(ii) Explain, using equations, the series of steps involved in the destruction of ozone, starting with a typical Freon, CF_2Cl_2 .
(iii) What are the environmental problems caused by these Freons? (30 marks)
- (c) When the atmosphere is loaded with large 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) What are the components that contribute to photochemical smog?
(ii) Write the physical characteristics of photochemical smog.
(iii) Briefly describe the effects of photochemical oxidants on humans, plants and materials. (40 marks)

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. (20 marks)

- (b)(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 in it. (25 marks)

- (c)(i) Define the term pE.
(ii) Briefly explain how pE varies with increasing depth in a stratified lake.
(iii) Given that the pE⁰ for the redox reaction:



is 4.75, calculate the pE value for a sediment-water interface containing FeCO₃(s) with a crust of black FeS(s) at pH = 8 in equilibrium with 1x10⁻⁴ mol dm⁻³ SO₄²⁻ and 1x10⁻² mol dm⁻³ HCO₃⁻. (30 marks)

- (d) The maximum safe limit of nitrate in drinking water is 45 ppm. A sample of 250.0 cm³ of water was analysed and found to contain 0.012 g of NO₃⁻. (N=14, O=16)

- (i) Calculate the concentration of NO₃⁻ in the sample in (I) mg dm⁻³
(II) mol dm⁻³.
(ii) Would the water be considered safe to drink? (25 marks)

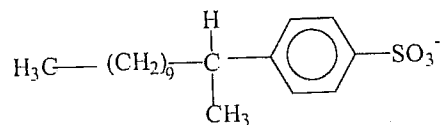
5. (a)(i) Write the main toxic metal ions and/or ligands that may be present in the effluents from the following industries:
food and beverages, electroplating and pesticides
(ii) Briefly describe the possible environmental consequences of the metal ions and/or ligands in (i).
(iii) What additional role the ligand plays in such an environment? (50 marks)

- (b)(i) Some components which are added in the preparation of a detergent are
(I) Surfactants (II) Water softeners
(III) Enzymes (IV) oxidants

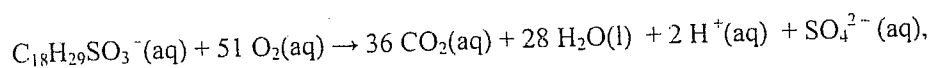
What role does each of these components play in a detergent?

- (ii) State three undesirable effects of non biodegradable detergents upon water treatment processes.

(iii) The following organic anion is found in most detergents.



If the anion undergoes aerobic decomposition according to equation



what is the total mass of O_2 required to biodegrade 1.0 g of the substance?

(Relative atomic masses; C = 12.00, H = 1.00, O = 16.00, S = 32.00)
(50 marks)

6. (a)(i) What do you mean by the term 'productivity' of a water body? (20 marks)
(ii) Briefly explain how it is related to water quality.

(b)(i) What determines the maximum amount of O_2 that can be dissolved in water?
(ii) Henry's law constant for O_2 at 25°C is $1.3 \times 10^{-3} \text{ mol dm}^{-3} \text{ atm}^{-1}$. If partial pressure of O_2 at this temperature is 0.21 atmosphere, calculate the amount of oxygen that is in equilibrium with atmosphere at 25°C in terms of
(I) mol dm^{-3} (II) ppm.

(iii) What is the biological oxygen demand of a water sample in which 10 mg of sugar ($\text{C}_{12}\text{H}_{22}\text{O}_{11}$) is dissolved in a litre of water? How does this compare with the O_2 solubility at 25°C ? (Organic matter of biological origin may be represented by $\{\text{CH}_2\text{O}\}$).
(Relative atomic masses; C = 12.00, H = 1.00, O = 16.00) (30 marks)

(c) Explain the following statements with special reference to the terms in **bold** print.

(i) Difluorobenzuron has an **LD₅₀ value** of 5 g /kg whereas methyl parathion has 5 mg/kg.
(ii) Environmental harm caused by **broad spectrum pesticides** is much more severe compared to **specific pesticides**. (20 marks)

(d)(i) Briefly describe the sources and environmental effects of the various radionuclides present in water.
(ii) A sample of water contaminated by the accidental discharge of a radionuclide used for medicinal purposes showed an activity of 12436 counts per second (cps) at the time of sampling and 8966 cps exactly 30 days later. What is the half-life of the radionuclide? (30 marks)