THE OPEN UNIVERSITY OF SRI LANKA

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

FINAL EXAMINATION- LEVEL 5- 2006/2007

CHU 3122/ CHE 5122- ENVIRONMENTAL CHEMISTRY
(2 ½ hours)

Thursday 9th November 2005	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) The atmosphere is subdivided into four major regions, according to the variation of
temperature with altitude. The troposphere is the region closer to the Earth.
   (i) Briefly describe the variation of temperature within the troposphere.
   (ii) Draw the temperature structure/profile of the troposphere.
   (iii) Sketch the temperature profile of the troposphere during a thermal inversion.
   (iv) Write any adverse effects during a thermal inversion episode.
   (v) Compare the characteristics of the troposphere with that of stratosphere.

   (50 marks)

(b)(i) What are the major gaseous constituents of fresh (clean) air?
   (ii) List three types of natural air pollutants and their sources.
   (iii) SO_2, NO_x, CO, particulates (solid and liquid), particulate Pb and O_3 are called criteria air
pollutants under the "Clean Air Act".
   (α) What are their major anthropogenic sources?
   (β) Distinguishing between primary air pollutants and secondary air pollutants, identify
   them from these pollutants.   (50 marks)

2. (a) Draw the oxygen cycle. How does human activities affect the oxygen cycle?

   (25 marks)

   (b)(i) Write the conditions necessary for the formation of photochemical smog.
   (ii) Account for the formation of ozone and aldehydes during photochemical
   smog. Write the harmful effects of ozone and aldehydes.   (25 marks)

   (c) Ozone is an oxidant and a secondary air pollutant and is a major cause for concern in the
troposphere.
   (i) Why is stratospheric ozone not considered as an air pollutant?
   (ii) Chlorofluorocarbons (CFC) form a group of compounds that is responsible for
   stratospheric ozone depletion.
   Name two other species that could cause depletion of stratospheric ozone.
   Write equations to show how these species catalyse ozone destruction.
   (iii) What harm is done by global ozone depletion?
   (iv) Once the dangers of Chlorofluorocarbons (CFC) were known, the world moved fast to
   agree to phase them out completely and meanwhile to produce alternative fluorocarbons
   as good substitutes for CFC. What other problem(s) would you expect these
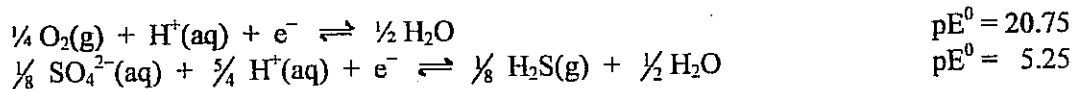   fluorocarbons to pose?   (50 marks)

3. (a)(i) Briefly discuss the role of the wavelength of light (visible vs. IR) as a factor in the 'natural greenhouse effect'.
(ii) "The growing of rice in Asia has contributed significantly to atmospheric methane".
Comment on the above statement.
What is the environmental consequence of such condition?
(iii) Write down the equations to show the fate of methane in the atmosphere.   (40 marks)

(b) The air in the city of Agra where Taj Mahal is located contains very high levels of pollutants that contribute to acid rain. The resulting acid rain is slowly decaying the monument, leaving the marble discoloured and lustreless. The Government of India took action to clean up the pollution that is destroying the country's best loved landmark.

(i) What is meant by acid rain?
(ii) What are the sources of these pollutants?
(iii) Write equations to show the processes that lead to acid rain.
(iv) What were the measures taken to clean up the city's air?
(v) Calculate the pH of rainwater in equilibrium with SO_2 in a polluted air mass for which the SO_2 concentration is 1.0 ppm. For SO_2, $K_H = 1.25$ mol dm^{-3} atm^{-1}. For H_2SO_3,
$pK_{a1} = 2.9$ and $pK_{a2} = 7.2$.   (60 marks)

4.(a)(i) Write down three of the unique properties of water. What are their effects on life?
(ii) Briefly describe the phenomenon 'thermal stratification'. How does it differ from 'overturn'?   (30 marks)

(b) Briefly discuss the sources and the environmental effects of the pollutant trace elements cadmium and arsenic in water.   (20 marks)

(c)(i) Going through a treatment plant, the initial oxygen demand of sewage 100 mg of O_2 dm^{-3} reduces by 50%. During the process, sewage is also diluted by a factor of 10. If the saturated concentration of oxygen in nearby lake is 8 mg of O_2 dm^{-3}, what is the expected concentration of oxygen in the lake when treated sewage is discharged? Assume that the total volume of the effluent discharged during the process is comparable with the capacity of the lake.

(ii) In treatment of sludge, the solids represented as $C_6H_{12}O_6$ are converted to methane gas and carbon dioxide as the only product. If 68 tons of solids are removed as sludge in a day, what is the volume of methane gas that can be produced at 298 K and 101.3 kPa?   (35 marks)
(1 ton = 1000 kg)

(d) Environmental marine pollution by oil spills has been a major problem reported in many parts of the world. Quick use of "dispersants" has been one of the remedial measures that has been taken to overcome this.
Explain why oil spills is a major environmental problem. What do you think is the role of dispersants?   (15 marks)

5.(a)(i) Write the main toxic metal ions and/or ligands that may be present in the effluents from the following industries:

paper and pulp, soap and detergents and leather

(ii) Briefly describe the possible environmental consequences of the metal ions and ligands in The above industries.

(iii) What is the role of ligand in such an environment? **(50 marks)**

(c) EDTA is a common chelating agent used for cleaning metal surfaces. During an analysis, it was found that waste water from such a cleaning process contained 4.5 mg dm^{-3} Cu(II) ions and excess EDTA at a level of 250 mg dm^{-3}. If EDTA ($M_r = 372$) is abbreviated as H_4Y and if Y^{4-} is the predominant species at pH 11 at which the analysis is carried out,

(i) Calculate the total molar concentration of EDTA in the waste water sample.

(ii) Calculate the total molar concentration of Cu (II) in the waste water sample (A_r, Cu = 63)

(iii) Write down the expression for the formation constant K_1 of Cu-EDTA complex at pH 11.

(iv) If the value of K_1 is given as 6.3×10^{18}, calculate the ratio of complexed copper to the uncomplexed copper

(v) Using the values in (ii) and (iv), calculate the concentration of uncomplexed Cu(II) ions. Comment on your answer in (iv) in an environmental context. **(50 marks)**

6.(a)(i) Briefly describe the sources and environmental effects of radionuclides in water.

(ii) Disposal of nuclear waste offers constant challenge to nuclear industry. One disposal method involves storing in sealed containers and burying them deep underground or in ocean beds.

How long would a waste containing ^{24}Na have to be stored for the concentration to be reduced to 0.1% of its initial value?

(Half- life for the decay of ^{24}Na is 15.0 hours) **(30 marks)**

(b)(i) Define the term pE and briefly explain the significance of pE- pH diagram.

(ii) Briefly explain how pE varies with increasing depth in a stratified lake.

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

$$\tfrac{1}{4} O_2(g) + H^+(aq) + e^- \rightleftharpoons \tfrac{1}{2} H_2O \qquad pE^0 = 20.75$$
$$\tfrac{1}{8} SO_4^{2-}(aq) + \tfrac{5}{4} H^+(aq) + e^- \rightleftharpoons \tfrac{1}{8} H_2S(g) + \tfrac{1}{2} H_2O \qquad pE^0 = 5.25$$

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

(i) 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.

(ii) 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). **(50 marks)**

(c) Briefly discuss major sources and health effects of Rn and carbon monoxide in the indoor atmosphere. **(20 marks)**

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