# The Open University of Sri Lanka
# Faculty of Natural Sciences
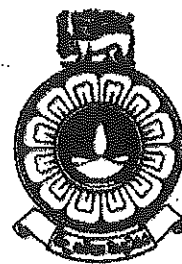
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| Department | : Chemistry |
| Level | : Level 5 |
| Name of the Examination | : Final Examination |
| Course Code and Title | : **CYU5309- Environmental Chemistry** |
| Academic Year | : 2021/22 |
| Date | : 14.10.2022 |
| Time | : 9.30 a.m. – 11.30 p.m. |
| Duration | : 02 Hours |

**General Instructions**

1. Read all instructions carefully before answering the questions.

2. This question paper consists of five (05) questions in four (04) pages.

3. Answer **all four (04)** questions. All questions carry equal marks.

4. Answer for each question should commence from a new page.

5. Draw fully labelled diagrams where necessary

6. Having any unauthorized documents/ mobile phones in your possession is a punishable offense

7. Use blue or black ink to answer the questions.

8. Circle the number of the questions you answered in the front cover of your answer script.

9. Clearly state your **index number** in your answer script

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1.A.  i.  Discuss the role of atmospheric nitrogen, oxygen, carbon dioxide and ozone (stratospheric) for sustaining the biosphere.

ii.  Sketch a profile of the temperature dependence with altitude in the troposphere and stratosphere.

**(20 marks)**

B.  i.  What is meant by the term "ozone depletion potential (ODP)"?

Trichlorofluoromethane, $CCl_3F$, is one of the CFC responsible for ozone depletion in the stratosphere. It is involved in a three-step mechanism described as follows.

    I.      Photolysis of $CCl_3F$.
    II.     Reaction between ozone and the radical formed in reaction (I).
    III.    Atomic oxygen contributes to Cl radical formation.

ii.    Write equations to show each step in this mechanism and explain how one CFC molecule destroys many ozone molecules.

iii.    What factors need to be considered when choosing a replacement for highly ozone depleting gas?

iii.    Explain why the ODP of $CHFCl_2$ (0.4) is lower than that of $CCl_3F$ (1.0).

**(25 marks)**


C.    i.    What do you mean by the term 'smog'?

ii.    Identify **five (05)** differences between oxidizing and reducing smog.

iii.    Identify **two (02)** primary pollutants that are formed during a photochemical smog. Describe how they are produced.

iv.    Identify **two (02)** secondary pollutants that are formed during photochemical smog. Describe how they are produced.

**(25 marks)**


D.    i.    What is meant by the term 'Indoor'?

ii.    The American Conference of Governmental Industrial Hygienists use "Threshold Limit Value" (TLV) term for the occupational exposure limit. What is meant by the term TLV?

iii.    Determine whether Threshold Limit value has been exceeded if a worker is exposed to an airborne mixture containing toluene at 25 ppm, xylene at 35 ppm and hexane at 15 ppm. Assume that similar toxic effects. Given that TLVs for toluene, xylene and hexane are 50 ppm, 100 ppm and 50 ppm respectively.

[Assumption: All the solvents will evapourate from the mixture and that the atmospheric concentration will resemble the original liquid fractions (extension of Raoult's Law)].
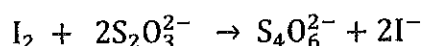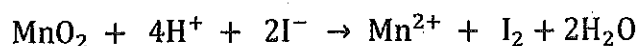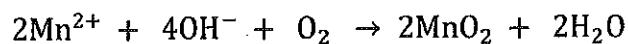
**(30 marks)**


2.A.    Alkalinity is important for fish and aquatic life because it protects or buffers against rapid pH changes.

i.    What is meant by the term "alkalinity" of water?

ii.    A sample of a water at pH 10.5 has 39.0 mg $L^{-1}$ of $CO_3^{2-}$ and 24 mg $L^{-1}$ of $HCO_3^{2-}$. Calculate total alkalinity (in mg $CaCO_3$ $L^{-1}$) of this sample [Atomic weight (g mol $^{-1}$): Ca = 40; O = 16; C = 12; H=1]

**(20 marks)**

B.    i.     What is meant by 5 – day Biochemical Oxygen Demand?

     ii.     Discuss the imporatnce of dissolved oxygen in aquatic systems

     iii     The oxygen concentration of a water sample can be determined by the Winkler titration method. In this method, the following reactions occur sequentially:

$$2Mn^{2+} + 4OH^- + O_2 \rightarrow 2MnO_2 + 2H_2O$$

$$MnO_2 + 4H^+ + 2I^- \rightarrow Mn^{2+} + I_2 + 2H_2O$$

$$I_2 + 2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2I^-$$

In determining the BOD$_5$ of a sample of a water, a student used two 10.0 mL samples of the same water, one before and one after the 5-day incubation period. They required 10.15 mL and 2.40 mL of a 0.010 M standard solution of K$_2$S$_2$O$_3$ respectively. Calculate the BOD$_5$ of this water sample.

**(20 marks)**

C.    i.     Describe stratification of a lake and how it changes the vertical profile of physical, chemical, and biological characteristics of the lake.

     ii.     What physical properties drive the stratification and turnover?

**(20 marks)**

D.    i.     Brifly describe what do you understand by the terms "Temporay Hardness" and "Permanent Hardness" of water.

     ii     A water sample (50.0 mL) consumed 15.0 mL of 0.01 M EDTA before boiling and 5.0 mL of the same EDTA after boiling. Calculate the total hardness, permanent hardness and temporary hardness.

**(20 marks)**

E.    Discuss the chemistry of acid mine drainage and its effects on the environment.
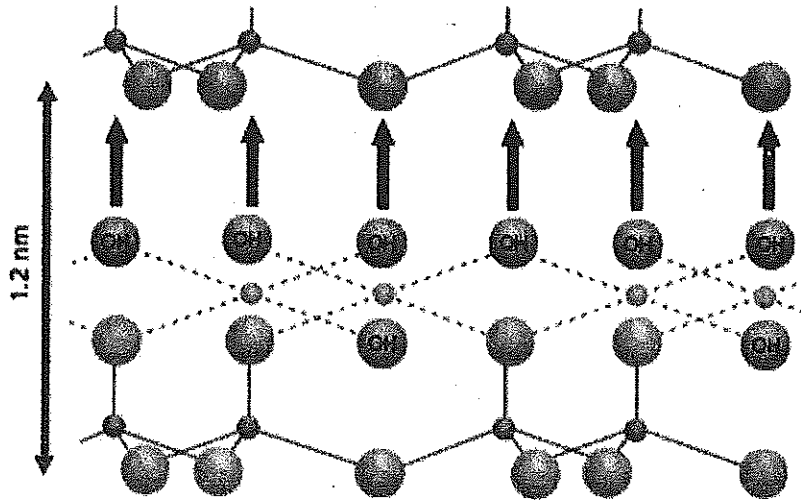
**(20 marks)**

3. A.    Acidification of soil is harmful to plants. It produces an imbalance in the uptake of cation and anion nutirents by the plants.

     i.     What is meant by acidification of soil?

     ii.     Give **three (03)** major sources of soil acidity?

     iii.     What are the consequences of soil acidity?

     iv.     Give **two** compounds that are commonly used to neutralize acid soils.

**(30 marks)**

B. i. Clay minerals are the characteristic minerals of the earth near surface environments. They form in soils and sediments and by digenetic and hydrothermal alteration of rocks. The structure of Kaiolinite is given below. Discuss its structure and properties.



ii. How do the soil minerals develop positive and negative charges on their surfaces?

(30 marks)

C. Describe **four (04)** mechanisms that are used by the microbes to degrade and transform of organic contaminants in soil. Give **one** example in each case.

(20 marks)

D. i. Explain what is meant by the term "Isomorphous substitution" in clay minerals.

ii. How does isomorphous substitution influence clay properties?

iii. Will isomorphous substitution help in plants growth?

(20 marks)

4. A. i. The atmospheric layer closest to the earth is referred to as the troposphere. Identify **five (05)** characteristic features of the troposphere.

ii. Fish kills are often found near the discharge point of water from water cooling systems from power plants. Explain this observation.
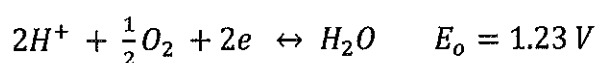
(20 marks)

B. i. Define the term Chemical Oxygen Demand (COD).

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ii. A sample of sewage water (25.0 mL) was treated with excess 50.0 mL of $K_2Cr_2O_7$. The unreacted $K_2Cr_2O_7$ was estimated using 0.25 M ferrous ammonium sulphate (FAS) solution. 18.0 mL FAS solution was consumed. Under similar conditions for blank titration, 30.0 mL of FAS solution was consumed. Calculate the COD of sewage water sample [Atomic weight of $O_2$ =32 g $mol^{-1}$]

**[Hint: the dichromate ion oxidizes 1.5 times the material that molecular $O_2$ does.]**

**(20 marks)**

C. i. What is meant by the term pE of an aquatic system?

ii. Calculate the pE value of sea water with respect to the following half reaction.

$$2H^+ + \frac{1}{2}O_2 + 2e \leftrightarrow H_2O \qquad E_o = 1.23\,V$$

(Assume pH = 8.1 and $P_{O_2} = 0.21\ atm\ in\ sea\ water$)

**(20 marks)**

D. Discuss the secondary biological treatement of wastewater.

**(20 marks)**

E. The cation exchange capacity (CEC) of soil arises due to the presence of both humic acid micelles and clay minerals. The CEC value of a soil is an important parameter to determine its quality.

i. Define the term "Cation Exchange Capacity" (CEC) of soil.

ii. Give **two (02)** important aspects of CEC in soil.

iii. The CEC of mineral Kaolinite is 10 m.eq./100 g sample whereas mineral Vermiculate has CEC of 140 m.eq./100 g sample. Account for the differences of CEC values.

**(20 marks)**

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